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### (54) **PROPYLENE POLYMER COMPOSITION**

PROPYLENPOLYMER ZUSAMMENSETZUNG

COMPOSITION POLYMERES DE PROPYLENE

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98101249.5 / 0 841 372**

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## Description

The present invention relates to propylene polymer compositions comprising two kinds of propylene polymers and to injection molded articles formed from propylene polymer compositions comprising two kinds of propylene polymers.

Propylene polymers have been conventionally molded by various molding methods and the molded articles have extensive uses.

The propylene polymers are generally prepared using a catalyst comprising a transition metal compound and an organoaluminum compound, i.e. a so-called Ziegler catalyst.

Propylene polymers prepared by the use of a titanium Ziegler catalyst containing a halogen-containing titanium catalyst component have excellent moldability and rigidity, but poor tensile elongation at break. Moreover, the titanium catalyst causes a large amount of catalyst residue in the resulting polymer because of its low polymerization activity, and hence the molded article is sometimes colored or has reduced sanitariness.

On the other hand, propylene polymers prepared by the use of a metallocene catalyst containing a transition metal compound catalyst component such as zirconocene have excellent tensile elongation at break, but poor moldability and rigidity (flexural modulus). However, the amount of the metallocene catalyst residue is small because of its high polymerization activity, and the molded article is never colored and has good sanitariness.

Though the characteristics required for the propylene polymers vary depending on the molding methods or uses, generally required are, for example, moldability, heat resistance, mechanical strength, high tensile elongation at break and impact resistance. For satisfying these requirements, research on various compositions such as a composition obtained by blending two or more kinds of propylene polymers and a composition obtained by blending a propylene polymer and other synthetic resin has been carried out.

For example, blending two propylene polymers which have different molecular weights has been carried out to improve the physical properties of the propylene polymers prepared by the use of a titanium catalyst. However, when two such propylene polymers are blended to prepare a propylene polymer composition, the tensile elongation at break of the resulting composition is markedly lowered, though the moldability is improved.

Further, adding a soft polymer to a propylene polymer which has been prepared by the use of a titanium catalyst has been carried out to improve the tensile elongation at break and the impact resistance of the propylene polymer. The soft polymer is, for example, an ethylene/propylene random copolymer prepared by the use of a titanium or vanadium catalyst. However, even if the propylene polymer prepared by the use of a titanium catalyst is blended with an ethylene/propylene random copolymer prepared by the use of, for example a titanium catalyst, the resulting composition does not have sufficiently improved tensile elongation at break and impact resistance.

EP-A-0 538 749 which is a prior art in the meaning of Art. 54 (3,4) EPC, discloses a propylene polymer composition comprising a propylene homopolymer having a Mw/Mn of less than 3 and a random propylene-olefin (ethylene) copolymer having a Mw/Mn of 3.5-10. The homopolymer is prepared by using a metallocene catalyst. The random copolymer is prepared by using a titanium catalyst. The composition can be melt extruded.

EP-A-0 433 990 discloses a propylene polymer composition comprising a crystalline propylene homopolymer and a propylene-ethylene copolymer having an ethylene content of 20-90 % by weight, said polymers being prepared by using bridged metallocenes. The composition has good impact strength.

As described above, conventional propylene polymer compositions do not always have satisfactory properties such as heat resistance, mechanical strength and tensile elongation at break.

The present invention seeks to provide propylene polymer compositions which have excellent heat resistance, mechanical strength and tensile elongation at break, for example, as compared with conventional propylene polymers or propylene polymer compositions.

The present invention provides a first propylene polymer composition comprising:

10 to 90 parts by weight of (A1) a propylene polymer which is characterized in that:

(1) the propylene polymer (A1) is obtained by polymerizing propylene in the presence of an olefin polymerization catalyst comprising:

(i)

(a) a compound of a Group IVB transition metal in the periodic table containing a ligand having a cyclopentadienyl skeleton, and

(ii) at least one compound selected from:

(b) an organoaluminum oxy-compound, and

(c) a compound which reacts with the transition metal compound (a) to form an ion pair,

(2) the propylene polymer (A1) has a melt flow rate (MFR), as measured at 230 °C under a load of 2.16 kg, of 0.01 to 30 g/10 min, and

(3) the propylene polymer (A1) has a molecular weight distribution (Mw/Mn), as measured by gel permeation chromatography (GPC), of 2 to 3; and

10 to 90 parts of weight of (A2) a propylene polymer which is characterized in that:

(1) the propylene polymer (A2) is obtained by polymerizing propylene in the presence of an olefin polymerization catalyst comprising:

(i)

(a) a compound of a Group IVB transition metal in the periodic table containing a ligand having a cyclopentadienyl skeleton, and

(ii) at least one compound selected from:

(b) an organoaluminum oxy-compound, and

(c) a compound which reacts with the transition metal compound (a) to form an ion pair,

(2) the propylene polymer (A2) has a melt flow rate (MFR), as measured at 230°C under a load of 2.16 kg, of 30 to 1,000 g/10 min, and

(3) the propylene polymer (A2) has a molecular weight distribution (Mw/Mn), as measured by gel permeation chromatography (GPC), of 2 to 4; and

3 to 30 parts by weight of (B) a soft polymer which is a (co)polymer of an  $\alpha$ -olefin of 2 to 20 carbon atoms having an MFR, as measured at 190°C under a load of 2.16 kg, of 0.01 to 100 g/10 min and a crystallinity, as measured by X-ray diffractometry, of less than 30%,

the ratio ((A2)/(A1)) of the MFR of said propylene polymer (A2) to the MFR of said propylene polymer (A1) being not less than 30.

Such propylene polymer compositions not only have excellent heat resistance, rigidity and tensile elongation at break but also excellent moldability and impact resistance.

The present invention also provides an injection molded article formed from a second propylene polymer composition comprising:

10 to 90% by weight of (A3) a propylene polymer which is characterized in that:

(1) the propylene polymer (A3) is obtained by polymerizing propylene in the presence of an olefin polymerization catalyst comprising:

(d) a solid titanium catalyst component, and

(e) an organometallic compound catalyst component,

(2) the propylene polymer (A3) has a melt flow rate (MFR), as measured at 230°C under a load of 2.16 kg, of 0.01 to 30 g/10 min, and

(3) the propylene polymer (A3) has a molecular weight distribution (Mw/Mn), as measured by gel permeation chromatography (GPC), of 4 to 15; and

the propylene polymer (A2) as defined above in an amount of 90 to 10% by weight.

The propylene polymer composition from which the article is molded has not only excellent heat resistance, rigidity and tensile elongation at break but also excellent moldability.

The present invention additionally provides a third propylene polymer composition comprising:

the propylene polymer (A3) as defined above, in an amount of 10 to 90 parts by weight;

the propylene polymer (A2) as defined above, in an amount of 90 to 10 parts by weight; and

(B) a soft polymer which is a (co)polymer of an  $\alpha$ -olefin of 2 to 20 carbon atoms having an MFR, as measured

at 190° under a load of 2.16 kg, of 0.01 to 100 g/10 min and a crystallinity, as measured by X-ray diffractometry, of less than 30%, in an amount of 3 to 30 parts by weight.

Such a propylene polymer composition has not only excellent heat resistance, rigidity and tensile elongation at break but also excellent moldability and impact resistance.

Fig. 1 illustrates the steps of a process for preparing an olefin polymerization catalyst which is used for the preparation of the propylene polymer (A1) and the propylene polymer (A2).

Fig. 2 illustrates the steps of a process for preparing an olefin polymerization catalyst which is used for the preparation of the propylene polymer (A3).

The invention will now be described in further detail.

The propylene polymer (A1) is a propylene homopolymer or copolymer obtained by the use of an olefin polymerization catalyst comprising a transition metal compound (a) and at least one compound selected from an organoaluminum oxy-compound (b) and a compound (c), all compounds being described later.

The propylene polymer (A1) has an MFR, as measured at 230°C under a load of 2.16 kg, of 0.01 to 30 g/10 min, preferably 0.5 to 5.0 g/10 min, and Mw/Mn, as measured by GPC, of 2 to 3.

Further, the propylene polymer (A1) desirably has an intrinsic viscosity  $[\eta]$  of 1.3 to 5.0 dl/g, preferably 2.0 to 4.0 dl/g, a weight-average molecular weight of  $12 \times 10^4$  to  $100 \times 10^4$ , preferably  $20 \times 10^4$  to  $70 \times 10^4$ , and a crystallinity, as measured by X-ray diffractometry, of not less than 40%, preferably not less than 50%.

The propylene polymer (A1) may contain constituent units derived from monomers other than propylene, such as ethylene and  $\alpha$ -olefins of 4 to 20 carbon atoms, e.g., 1-butene, 1-pentene, 1-hexene, 4-methyl-1-pentene, 1-octene, 1-decene, 1-dodecene, 1-tetradecene, 1-hexadecene, 1-octadecene and 1-eicosene, in an amount of not more than 10% by mol.

#### Propylene polymer (A2)

The propylene polymer (A2) is a propylene homopolymer or copolymer obtained by the use of an olefin polymerization catalyst comprising a transition metal compound (a) and at least one compound selected from an organoaluminum oxy-compound (b) and a compound (c), all compounds being described later.

The propylene polymer (A2) has an MFR, as measured at 230°C under a load of 2.16 kg, of 30 to 1,000 g/10 min, preferably 50 to 200 g/10 min, and Mw/Mn, as measured by GPC, of 2 to 4.

Further, the propylene polymer (A2) desirably has an intrinsic viscosity  $[\eta]$  of not less than 0.5 and less than 1.3 dl/g, preferably not less than 0.8 and less than 1.3 dl/g, a weight-average molecular weight of  $5 \times 10^3$  to  $15 \times 10^4$ , preferably  $1 \times 10^4$  to  $12 \times 10^4$ , and a crystallinity, as measured by X-ray diffractometry, of not less than 40%, preferably not less than 50%.

The propylene polymer (A2) may contain constituent units derived from monomers other than propylene, which are exemplified for the propylene polymer (A1), in an amount of not more than 5% by mol.

#### Soft Polymer (B)

The soft polymer (B) is a (co)polymer of an  $\alpha$ -olefin of 2 to 20 carbon atoms, and has an MFR, as measured at 190°C under a load of 2.16 kg, of 0.01 to 100 g/10 min, preferably 0.05 to 50 g/10 min. This soft polymer (B) has a crystallinity, as measured by X-ray diffractometry, of less than 30%, and desirably is amorphous.

Examples of the  $\alpha$ -olefins of 2 to 20 carbon atoms include ethylene, propylene, 1-butene, 1-pentene, 1-hexene, 4-methyl-1-pentene, 1-octene, 1-decene and mixtures thereof. Of these, particularly preferred are  $\alpha$ -olefins of 1 to 10 carbon atoms.

The soft polymer (B) is preferably a copolymer of ethylene and an  $\alpha$ -olefin, and the  $\alpha$ -olefin is for example an  $\alpha$ -olefin of 3 to 20 carbon atoms, preferably an  $\alpha$ -olefin of 3 to 6 carbon atoms, particularly preferably propylene.

The soft polymer (B) may contain constituent units other than the constituent units derived from  $\alpha$ -olefins, such as those derived from diene compounds, with the proviso that the characteristics thereof are not marred.

Examples of the other constituent units include constituent units derived from:

chain non-conjugated dienes, such as 1,4-hexadiene, 1,6-octadiene, 2-methyl-1,5-hexadiene, 6-methyl-1,5-heptadiene and 7-methyl-1,6-octadiene;

cyclic non-conjugated dienes, such as cyclohexadiene, dicyclopentadiene, methyltetrahydroindene, 5-vinylbornene, 5-ethylidene-2-norbornene, 5-methylene-2-norbornene, 5-isopropylidene-2-norbornene and 6-chloromethyl-5-isopropenyl-2-norbornene; and

diene compounds, such as 2,3-diisopropylidene-5-norbornene, 2-ethylidene-3-isopropylidene-5-norbornene and 2-propenyl-2,2-norbornadiene.

These diene components can be used singly or in combination. The content of the diene component is usually not more than 10% by mol, preferably 0 to 5% by mol.

The soft polymer (B) is, for example, a copolymer containing constituent units derived from ethylene in an amount of 0 to 95% by mol, preferably 30 to 92% by mol, more preferably 40 to 90% by mol, constituent units derived from an  $\alpha$ -olefin of 3 to 20 carbon atoms in an amount of 1 to 100% by mol, preferably 4 to 70% by mol, more preferably 8 to 60% by mol, and constituent units derived from a diene component in an amount of 0 to 10% by mol, preferably 0 to 5% by mol, more preferably 0 to 3% by mol.

The soft polymer (B) can be prepared by conventionally known processes using, for example, a titanium, vanadium or zirconium catalyst.

#### Propylene polymer composition

The first propylene polymer composition comprises the propylene polymer (A1), the propylene polymer (A2) and the soft polymer (B). The propylene polymer (A1) is contained in an amount of 10 to 90 parts by weight, preferably 30 to 70 parts by weight; the propylene polymer (A2) is contained in an amount of 10 to 90 parts by weight, preferably 30 to 70 parts by weight; and the soft polymer (B) is contained in an amount of 3 to 30 parts by weight, preferably 10 to 25 parts by weight. The ratio [(A2)/(A1)] of the MFR of the propylene polymer (A2) to the MFR of the propylene polymer (A1) is not less than 30, preferably 40 to 300, more preferably 50 to 100.

The first propylene polymer composition desirably has an MFR, as measured at 230°C under a load of 2.16 kg, of 1 to 100 g/10 min, preferably 5 to 50 g/10 min. In this composition, Mw/Mn of all the propylene components constituting the composition is desirably 4 to 15.

The density of the first propylene polymer composition is desirably 0.88 to 0.92 g/cm<sup>3</sup>, preferably 0.89 to 0.92 g/cm<sup>3</sup>.

The heat distortion temperature (HDT) is desirably not lower than 80°C, preferably 90 to 140°C.

The flexural modulus (FM) is desirably 8,500 to 18,000 kg/cm<sup>2</sup>, preferably 9,000 to 15,000 kg/cm<sup>2</sup>.

The Izod impact strength (IZ) at 23°C is desirably 10 to 50 kg-cm/cm, preferably 10 to 40 kg-cm/cm.

The tensile elongation at break (EL) is desirably 200 to 1,000%, preferably 300 to 1,000%.

The first propylene polymer composition may contain additives, if necessary, such as a weathering stabilizer, heat stabilizer, antistatic agent, anti-slip agent, anti-blocking agent, anti-fogging agent, lubricant, pigment, dye, nucleating agent, plasticizer, anti-aging agent, hydrochloric acid absorber and antioxidant, with the proviso that the object of the invention is not marred.

The first propylene polymer composition can be prepared by conventionally known processes, for example:

(1) A process comprising mechanically blending the propylene polymer (A1), the propylene polymer (A2), the soft polymer (B) and, if desired, other components by, for example, an extruder or a kneader.

(2) A process comprising dissolving the propylene polymer (A1), the propylene polymer (A2), the soft polymer (B) and, if desired, other components in an appropriate good solvent (e.g., hydrocarbon solvents such as hexane, heptane, decane, cyclohexane, benzene, toluene and xylene), and removing the solvent.

(3) A process comprising individually dissolving the propylene polymer (A1), the propylene polymer (A2), the soft polymer (B) and, if desired, other components in appropriate good solvents respectively to give solutions, then mixing the solutions, and removing the solvents.

(4) A process comprising the above processes (1) to (3) in combination.

(5) A process comprising conducting the polymerization in three or more steps having different reaction conditions, in the first step of which the propylene polymer (A1) is prepared, in the second of which the propylene polymer (A2) is prepared, and in the third of which the soft polymer (B) is prepared; alternatively, using plural polymerizers, in one polymerizer of which the propylene polymer (A1) is prepared, and another polymerizer of which the propylene polymer (A2) is prepared and in another polymerizer of which the soft polymer (B) is prepared.

(6) A process in which a composition of the propylene polymer (A1) and the propylene polymer (A2), which have been beforehand prepared in the following manner, is formed and then the resulting composition is blended with the soft polymer (B) in accordance with the aforesaid processes.

The composition of the propylene polymer (A1) and the propylene polymer (A2) can be produced by a process comprising conducting the polymerization in two or more steps having different reaction conditions, in one step of which the propylene polymer (A1) is prepared and in another step of which the propylene polymer (A2) is prepared, or a process comprising using plural polymerizers, in one polymerizer of which the propylene polymer (A1) is prepared and in another polymerizer of which the propylene polymer (A2) is prepared.

The first propylene polymer composition has not only excellent heat resistance, rigidity and tensile elongation at break but also excellent moldability and impact resistance. Further, since the amount of the catalyst residue in the polymer composition is small, the article molded from the composition is never colored and has good sanitariness.

Next, the olefin polymerization catalyst used in the preparation of the propylene polymers (A1) and (A2) and the process for preparing the propylene polymers (A1) and (A2) are described.

The propylene polymers (A1) and (A2) can be prepared by polymerizing propylene in the presence of an olefin polymerization catalyst [olefin polymerization catalyst (1)] comprising:

- (i) a compound of a Group IVB transition metal of the periodic table containing a ligand having a cyclopentadienyl skeleton, and
- (ii) at least one compound selected from:
  - (b) an organoaluminum oxy-compound, and
  - (c) a compound which reacts with the transition metal compound (a) to form an ion pair.

Fig. 1 illustrates steps of a process for preparing the olefin polymerization catalyst which is used for the preparation of the propylene polymers (A1) and (A2).

Examples of the compound (a) of the Group IVB transition metal of the periodic table include the transition metal compounds represented by the following formulae (Ia) and (I) :



wherein M is titanium, zirconium, hafnium, vanadium, niobium, tantalum or chromium, preferably titanium, zirconium or hafnium, and x is a valence of the transition metal atom.

L is a ligand coordinating to the transition metal, at least one of L is a ligand having a cyclopentadienyl skeleton, and preferably at least two of L are ligands having a cyclopentadienyl skeleton.

The ligands having a cyclopentadienyl skeleton are, for example, a cyclopentadienyl group, indenyl group, 4,5,6,7-tetrahydroindenyl group, 4,5,6,6a-tetrahydropentarenyl group, 7,8-dihydro-3H.6H-as-indacenyl group and fluorenyl group. These groups as exemplified above may be substituted with an alkyl group, an aryl group, an aralkyl group, a trialkylsilyl group, a halogen atom, an alkoxy group, an aryloxy group, a linear alkylene group or a cyclic alkylene group. Further, these groups having a cyclopentadienyl skeleton may form a ring condensate with a benzene ring, naphthalene ring, acenaphthene ring or indene ring.

Of the ligands coordinating with the transition metal atom, preferred is a ligand having an indenyl skeleton, and particularly preferred is ligand having a substituted indenyl skeleton.

When the transition metal compound of formula (Ia) contains 2 or more ligands each having a cyclopentadienyl skeleton, the two ligands may be linked together through:

- an alkylene group such as ethylene or propylene;
- a substituted alkylene group such as 1,2-di(methyl)ethylene;
- a cycloalkylene group such as 1,4-cyclohexylene or 1,3-cyclopentylene;
- a substituted alkylidene group such as isopropylidene or diphenylmethylenes;
- a silylene group;
- a substituted silylene group such as dimethylsilylene, diphenylsilylene or methylphenylsilylene;
- a germyl group;
- P(R<sup>a</sup>)-, -P(O)(R<sup>b</sup>)-, SO<sub>2</sub>N-(R<sup>c</sup>)- or Sn(R<sup>d</sup>)<sub>2</sub>- [wherein each of R<sup>a</sup>, R<sup>c</sup> and R<sup>d</sup> is an alkyl group, and R<sup>b</sup> is an aryl group].

Of these, particularly preferred are ligands linked together through a substituted silylene group such as a dimethylsilylene group, diphenylsilylene group or methylphenylsilylene group.

Example the ligands L other than those having a cyclopentadienyl skeleton include:

- a hydrocarbon group of 1-10 carbon atoms such as an alkyl group (e.g. methyl group, ethyl group, propyl group, isopropyl group, butyl group, pentyl group or neopentyl group), a cycloalkyl group (e.g. cyclopentyl group or cyclohexyl group), an aryl group (e.g. phenyl group, tolyl group or mesityl group) and an aralkyl group (e.g. benzyl or neophyl),
- an alkoxy group of 1-10 carbon atoms such as methoxy group, ethoxy group, propoxy group or butoxy group,
- an aryloxy group of 6-10 carbon atoms such as phenoxy group,
- a ligand represented by -OSO<sub>2</sub>R<sup>e</sup> or -CH<sub>2</sub>SiR<sup>e</sup><sub>3</sub> (wherein R<sup>e</sup> is a hydrocarbon group of 1-10 carbon atoms) such as mesitylsulfonate, phenylsulfonate, benzylsulfonate, methylsulfonate, p-toluenesulfonate or trifluoromethanesul-

fonate,

a halogen atom such as fluorine, chlorine, bromine or iodine, and  
a hydrogen atom.

When the transition metal compound contains 2 or more ligands other than those having a cyclopentadienyl skeleton, each ligand may be the same or different.

When the valence of the transition metal atom is, for example, 4, the transition metal compound of formula (1a) is represented by formula (1b):



wherein M represents the above mentioned transition metal atom,  $R^4$  represents a ligand having a cyclopentadienyl skeleton as in formula (1a),  $R^5$ ,  $R^6$  and  $R^7$  each represent a ligand having a cyclopentadienyl skeleton or a ligand L other than those having a cyclopentadienyl skeleton, k is an integer of 1 or more, and  $k+l+m+n=4$ .

In the present invention, there is preferably used a transition metal compound of formula (1b) in which at least two of  $R^4$ ,  $R^5$ ,  $R^6$  and  $R^7$  are substituted indenyl groups. In this case, these groups are preferably linked together through a group as in formula (1a).

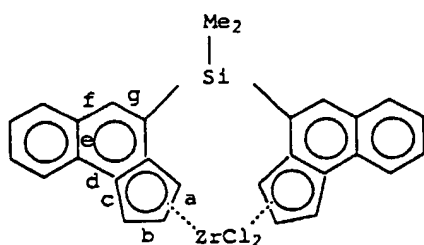
Exemplified below are transition metal compounds wherein M is zirconium.

rac-ethylene-bis{1-(2-methylindenyl)}zirconium dichloride,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium dichloride,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium dihydride,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium difluoride,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium dibromide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium diiodide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium dimethoxide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium di-n-butoxide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium diphenoxide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium di-t-butoxide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium dimethyl,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium dineopentyl,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium ditrimethylsilylmethyl,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium ditosylate,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium dimesilate,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium di(mesitylsulfonate),  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium di(phenylsulfonate),  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium di(benzylsulfonate),  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium di(trifluoromethanesulfonate),  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride monohydride,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride monofluoride,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride monobromide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride moniodide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride monomethoxide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride mono-n-butoxide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride monophenoxide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride mono-t-butoxide,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride monomethyl,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride mononeopentyl,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride monotrimethylsilylmethyl,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride monotosylate,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride monomesilate,  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride mono(mesitylsulfonate),  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride mono(phenylsulfonate),  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride mono(benzylsulfonate),  
rac-dimethylsilylene-bis{1-(2-methylindenyl)}zirconium monochloride mono(trifluoromethanesulfonate),  
rac-diphenylsilylene-bis{1-(2-methylindenyl)}zirconium dichloride,

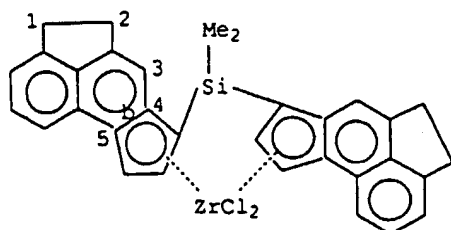
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 rac-phenylphosphinylene-bis{1-(2-methylindenyl)}zirconium dichloride,  
 5 rac-ethylene-bis{1-(2,4-dimethylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-methyl, 4-isopropylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2,4-dimethylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl, 4-ethylindenyl)}zirconium dichloride,  
 10 rac-dimethylsilylene-bis{1-(2-methyl, 4-n-propylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl, isopropylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl, 4-n-butylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl, 4-i-butylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl, 4-t-butylindenyl)}zirconium dichloride,  
 15 rac-dimethylsilylene-bis{1-(2-methyl, 4-trimethylsilylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl, 4-isopropylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-n-propyl, 4-isopropylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-i-propyl, 4-isopropylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-n-butyl, 4-isopropylindenyl)}zirconium dichloride,  
 20 rac-dimethylsilylene-bis{1-(2-i-butyl, 4-isopropylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-t-butyl, 4-isopropylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-trimethylsilyl, 4-isopropylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-phenyl, 4-isopropylindenyl)}zirconium dichloride,  
 rac-diphenylsilylene-bis{1-(2,4-dimethylindenyl)}zirconium dichloride,  
 25 rac-diphenylsilylene-bis{1-(2-methyl, 4-isopropylindenyl)}zirconium dichloride,  
 rac-methylphenylsilylene-bis{1-(2, 4-dimethylindenyl)}zirconium dichloride,  
 rac-methylphenylsilylene-bis{1-(2-methyl, 4-isopropylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2, 5-dimethylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-methyl, 5-isopropylindenyl)}zirconium dichloride,  
 30 rac-dimethylsilylene-bis{1-(2,5-dimethylindenyl)}zirconium dichloride,  
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 rac-dimethylsilylene-bis{1-(2-methyl, 6-isopropylindenyl)}zirconium dichloride,  
 40 rac-diphenylsilylene-bis{1-(2,6-dimethylindenyl)}zirconium dichloride,  
 rac-diphenylsilylene-bis{1-(2-methyl, 6-isopropylindenyl)}zirconium dichloride,  
 rac-methylphenylsilylene-bis{1-(2,6-dimethylindenyl)}zirconium dichloride,  
 rac-methylphenylsilylene-bis{1-(2-methyl, 6-isopropylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2,4,5-trimethylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-isopropyl-4,5-dimethylindenyl)}zirconium dichloride,  
 45 rac-dimethylsilylene-bis{1-(2,4,5-trimethylindenyl)}zirconium dichloride,  
 rac-diphenylsilylene-bis{1-(2,4,5-trimethylindenyl)}zirconium dichloride,  
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 rac-ethylene-bis{1-(2,5,6-trimethylindenyl)}zirconium dichloride,  
 50 rac-dimethylsilylene-bis{1-(2,5,6-trimethylindenyl)}zirconium dichloride,  
 rac-diphenylsilylene-bis{1-(2,5,6-trimethylindenyl)}zirconium dichloride,  
 rac-methylphenylsilylene-bis{1-(2,5,6-trimethylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-methyl-5-t-butylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl-5-t-butylindenyl)}zirconium dichloride,  
 55 rac-methylphenylsilylene-bis{1-(2-methyl-5-t-butylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-methyl-6-t-butylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl-6-t-butylindenyl)}zirconium dichloride,  
 rac-diphenylsilylene-bis{1-(2-methyl-6-t-butylindenyl)}zirconium dichloride,



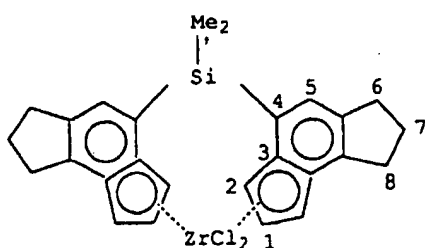
rac-methylphenylsilylene-bis{1-(2-methyl-6-t-butylindenyl)}zirconium dichloride,  
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 rac-dimethylsilylene-bis{1-(2-methyl-5,6-di-t-butylindenyl)}zirconium dichloride,  
 rac-diphenylsilylene-bis{1-(2-methyl-5,6-di-t-butylindenyl)}zirconium dichloride,  
 5 rac-methylphenylsilylene-bis{1-(2-methyl-5,6-di-t-butylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-methyl-5-trimethylsilylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl-5-trimethylsilylindenyl)}zirconium dichloride,  
 rac-diphenylsilylene-bis{1-(2-methyl-5-trimethylsilylindenyl)}zirconium dichloride,  
 10 rac-methylphenylsilylene-bis{1-(2-methyl-5-trimethylsilylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-methyl-6-trimethylsilylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl-6-trimethylsilylindenyl)}zirconium dichloride,  
 rac-diphenylsilylene-bis{1-(2-methyl-6-trimethylsilylindenyl)}zirconium dichloride,  
 rac-methylphenylsilylene-bis{1-(2-methyl-6-trimethylsilylindenyl)}zirconium dichloride,  
 15 rac-ethylene-bis{1-(2-methyl-5,6-bistrimethylsilylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl-5,6-bistrimethylsilylindenyl)}zirconium dichloride,  
 rac-diphenylsilylene-bis{1-(2-methyl-5,6-bistrimethylsilylindenyl)}zirconium dichloride,  
 rac-methylphenylsilylene-bis{1-(2-methyl-5,6-bistrimethylsilylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-methyl-5,6-bistriphenylsilylindenyl)}zirconium dichloride,  
 20 rac-dimethylsilylene-bis{1-(2-methyl-5,6-bistriphenylsilylindenyl)}zirconium dichloride, rac-ethylene-bis{1-(2-methyl-4-methoxyindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl-4-methoxyindenyl)}zirconium dichloride,  
 rac-diphenylsilylene-bis{1-(2-methyl-4-methoxyindenyl)}zirconium dichloride,  
 rac-methylphenylsilylene-bis{1-(2-methyl-4-methoxyindenyl)}zirconium dichloride,  
 25 rac-dimethylsilylene-bis{1-(2-methyl-5-methoxyindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-methyl-6-methoxyindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-methyl-5,6-dimethoxyindenyl)}zirconium dichloride,  
 ethylene-bis{1-(2-methyl-4,5,6,7-tetrahydroindenyl)}zirconium dichloride,  
 dimethylsilylene-bis{1-(4,5,6,7-tetrahydroindenyl)}zirconium dichloride,  
 30 dimethylsilylene-bis{1-(2-methyl-4,5,6,7-tetrahydroindenyl)}zirconium dichloride,  
 dimethylsilylene-bis{1-(2-methylcyclopentadienyl)}zirconium dichloride,  
 dimethylsilylene-bis{1-(3-methylcyclopentadienyl)}zirconium dichloride,  
 dimethylsilylene-bis{1-(4-methylcyclopentadienyl)}zirconium dichloride,  
 dimethylsilylene-bis{1-(5-methylcyclopentadienyl)}zirconium dichloride,  
 35 dimethylsilylene-bis{1-(2,4-dimethylcyclopentadienyl)}zirconium dichloride,  
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 dimethylsilylene-bis{1-(2,4,5-trimethylcyclopentadienyl)}zirconium dichloride,



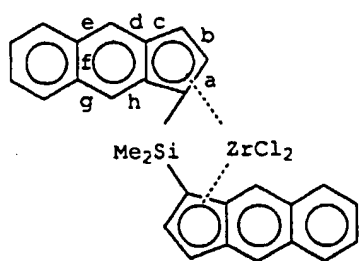
dimethylsilylene-  
 bis(benzo[e]indenyl)  
 zirconium dichloride



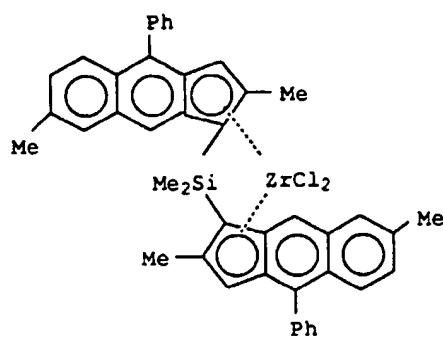
dimethylsilylene-bis(1,2-dihydroacenaphthyl[4,5-b]cyclopentadienyl)zirconium dichloride



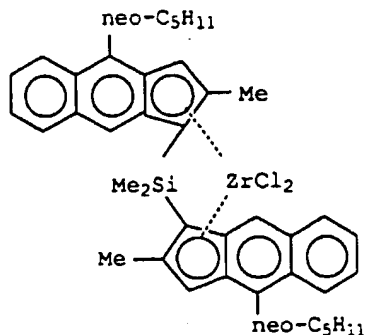
dimethylsilylene-bis(7,8-dihydro-3H,6H-3-as-indathenyl)zirconium dichloride



dimethylsilylene-bis(benzo[f]indenyl)zirconium dichloride



dimethylsilylene-bis(1-(toluo[4,3-f]-2-methyl-4-phenylindenyl)zirconium dichloride

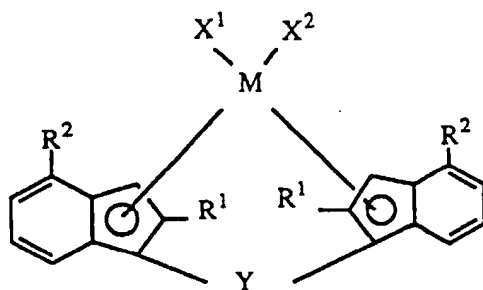


dimethylsilylene-bis(1-(benzo[f]-2-methyl-4-neopentylindenyl)zirconium dichloride

There may also be used the compounds obtained by substituting titanium, hafnium, vanadium, niobium, tantalum or chromium for zirconium in the above-exemplified zirconium compounds.

Of the transition metal compounds of formula (Ia), preferred are those having zirconium as the central metal atom and having at least two ligands containing an indenyl skeleton.

The transition metal compounds preferably used as the transition metal compound (a) are those of formula (I):



(I)

wherein M is a transition metal atom of Group IVB of the periodic table. Examples of the transition metal atoms include titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum and tungsten. Of these, preferred are titanium, zirconium and hafnium, and particularly preferred is zirconium.

R<sup>1</sup> is a hydrocarbon group of 2 to 6 carbon atoms. Examples of the hydrocarbon groups include an alkyl group such as ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl, n-pentyl, neopentyl, n-hexyl and cyclohexyl; and an alkenyl group such as vinyl and propenyl.

Of these, preferred are alkyl groups whose carbon atom bonded to the indenyl group is a primary carbon atom, more preferred are alkyl groups of 2 to 4 carbon atoms whose carbon atom bonded to the indenyl group is a primary carbon atom, and particularly preferred is ethyl.

R<sup>2</sup> is an aryl group of 6 to 16 carbon atoms. Examples of the aryl groups include phenyl,  $\alpha$ -naphthyl,  $\beta$ -naphthyl, anthracenyl, phenanthryl, pyrenyl, acenaphthyl, phenarenyl, aceanthryrenyl, tetrahydronaphthyl and indanyl. Of these, preferred are phenyl, naphthyl, anthracenyl and phenanthryl.

These aryl groups may be substituted with:

halogen atoms, such as fluorine, chlorine, bromine and iodine;

hydrocarbon groups of 1 to 20 carbon atoms, such as alkyl groups (e.g., methyl, ethyl, propyl, butyl, hexyl, cyclohexyl, octyl, nonyl, dodecyl, icosyl, norbornyl and adamantyl), alkenyl groups (e.g., vinyl, propenyl and cyclohexenyl), arylalkyl groups (e.g., benzyl, phenylethyl and phenylpropyl) and aryl groups (e.g., phenyl, tolyl, dimethylphenyl, trimethylphenyl, ethylphenyl, propylphenyl, biphenyl, naphthyl, methylnaphthyl, anthracenyl and phenanthryl); and

organosilyl groups, such as trimethylsilyl, triethylsilyl and triphenylsilyl.

X<sup>1</sup> and X<sup>2</sup> are each a hydrogen atom, a halogen atom, a hydrocarbon group of 1 to 20 carbon atoms, a halogenated hydrocarbon group of 1 to 20 carbon atoms, an oxygen-containing group or a sulfur-containing group. As the halogen atom and the hydrocarbon group of 1 to 20 carbon atoms, the aforesaid atoms and groups can be exemplified. As the halogenated hydrocarbon group of 1 to 20 carbon atoms, groups obtained by substituting the aforesaid hydrocarbon groups with halogen atoms can be exemplified.

Examples of the oxygen-containing groups include a hydroxy group; alkoxy groups such as methoxy, ethoxy, propoxy and butoxy; aryloxy groups such as phenoxy, methylphenoxy, dimethylphenoxy and naphthoxy; and arylalkoxy groups such as phenylmethoxy and phenylethoxy.

Examples of the sulfur-containing groups include substituents obtained by substituting sulfur for oxygen in the above-mentioned oxygen-containing groups; sulfonate groups such as methylsulfonate, trifluoromethanesulfonate, phenylsulfonate, benzyisulfonate, p-toluenesulfonate, trimethylbenzenesulfonate, triisobutylbenzenesulfonate, p-chlorobenzenesulfonate and pentafluorobenzenesulfonate; and sulfinat groups such as methylsulfinat, phenylsulfinat, benzenesulfonate, p-toluenesulfinat, trimethylbenzenesulfinat and pentafluorobenzenesulfinat.

Of these, preferred are halogen atoms and hydrocarbon groups of 1 to 20 carbon atoms.

Y is a divalent hydrocarbon group of 1 to 20 carbon atoms, a divalent halogenated hydrocarbon group of 1 to 20 carbon atoms, a divalent silicon-containing group, a divalent germanium-containing group, a divalent tin-containing group, -O-, -CO-, -S-, -SO<sub>2</sub>-, -SO<sub>2</sub>-, -NR<sup>3</sup>-, -P(R<sup>3</sup>)-, -P(O)(R<sup>3</sup>)-, -BR<sup>3</sup>- or -AlR<sup>3</sup>- (R<sup>3</sup> is a hydrogen atom, a halogen atom, a hydrocarbon group of 1 to 20 carbon atoms or a halogenated hydrocarbon group of 1 to 20 carbon atoms). More specifically, there can be mentioned:

divalent hydrocarbon groups of 1 to 20 carbon atoms, such as alkylene groups, e.g., methylene, dimethylmethylene, 1,2-ethylene, dimethyl-1,2-ethylene, 1,3-trimethylene, 1,4-tetramethylene and 1,2-cyclohexylene, 1,4-cyclohexylene, and arylalkylene groups, e.g., diphenylmethylene and diphenyl-1,2-ethylene;

halogenated hydrocarbon groups obtained by halogenating the above-mentioned divalent hydrocarbon groups of 1 to 20 carbon atoms, such as chloromethylene;

divalent silicon-containing groups, such as alkylsilylene, alkylarylsilylene and arylsilylene groups, e.g., methylsilylene, dimethylsilylene, diethylsilylene, di(n-propyl)silylene, di(i-propyl)silylene, di(cyclohexyl)silylene, methylphenylsilylene, diphenylsilylene, di(p-tolyl)silylene and di(p-chlorophenyl)silylene, and alkylidisilyl, alkylaryldisilyl and arylidisilyl groups, e.g., tetramethyl-1,2-disilyl and tetraphenyl-1,2-disilyl;

divalent germanium-containing groups obtained by substituting germanium for silicon in the above-mentioned divalent silicon-containing groups; and

divalent tin-containing groups obtained by substituting tin for silicon in the above-mentioned divalent silicon-containing groups.

R<sup>3</sup> is the same halogen atom, the same hydrocarbon group of 1 to 20 carbon atoms or the same halogenated hydrocarbon group of 1 to 20 carbon atoms as described above.

Of these, preferred are divalent silicon-containing groups, divalent germanium-containing groups and divalent tin-containing groups; more preferred are divalent silicon-containing groups; and most preferred are alkylsilylene, alkylarylsilylene and arylsilylene.

Exemplified below are the transition metal compounds of formula (I).

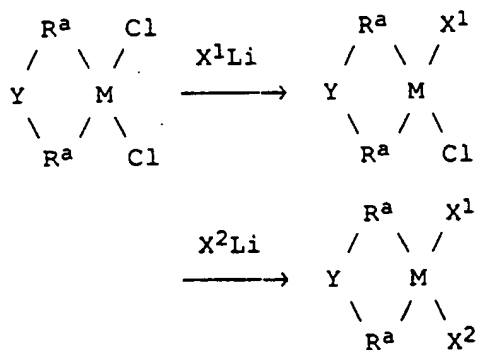
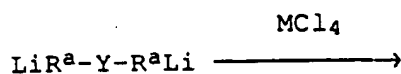
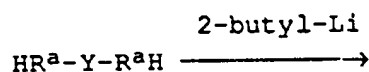
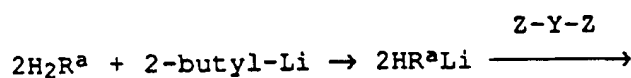
rac-dimethylsilylene-bis{1-(2-ethyl-4-phenylindenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-( $\alpha$ -naphthyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-( $\beta$ -naphthyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(2-methyl-1-naphthyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(5-acenaphthyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(9-anthracenyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(9-phenantoryl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(o-methylphenyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(m-methylphenyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(p-methylphenyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(2,3-dimethylphenyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(2,4-dimethylphenyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(2,5-dimethylphenyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(2,4,6-trimethylphenyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(o-chlorophenyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(m-chlorophenyl)indenyl)}zirconium dichloride,  
 rac-dimethylsilylene-bis{1-(2-ethyl-4-(p-chlorophenyl)indenyl)}zirconium dichloride,



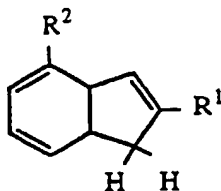
rac-methylene-bis{1-(2-ethyl-4-phenylindenyl)}zirconium dichloride,  
 rac-methylene-bis{1-(2-ethyl-4-( $\alpha$ -naphthyl)indenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-ethyl-4-phenylindenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-ethyl-4-( $\alpha$ -naphthyl)indenyl)}zirconium dichloride,  
 rac-ethylene-bis{1-(2-n-propyl-4-( $\alpha$ -naphthyl)indenyl)}zirconium dichloride,  
 rac-dimethylgermyl-bis{1-(2-ethyl-4-phenylindenyl)}zirconium dichloride,  
 rac-dimethylgermyl-bis{1-(2-ethyl-4-( $\alpha$ -naphthyl)indenyl)}zirconium dichloride, and  
 rac-dimethylgermyl-bis{1-(2-n-propyl-4-phenylindenyl)}zirconium dichloride.

There may also be used the transition metal compounds obtained by substituting titanium metal, hafnium metal, vanadium metal, niobium metal, tantalum metal, chromium metal, molybdenum metal or tungsten metal for zirconium metal in the above-exemplified compounds.

The transition metal compounds of formula (I) can be prepared in accordance with the methods described in Journal of Organometallic Chem. 288 (1985), pages 63 to 67, and EP-B-320,762, for instance, in the following manner.



wherein, Z represents Cl, Br, I or o-tosyl group, and  $\text{H}_2\text{R}^a$  represents



Though the transition metal compounds of formula (I) are usually used in the form of a racemic mixture, the R-type or S-type may also be used.

These transition metal compounds may be used singly or in a combination of two or more. Further, they may be diluted in a hydrocarbon or halogenated hydrocarbon.

The organoaluminum oxy-compound (b) which forms the olefin polymerization catalyst (1) for polymerization of

the propylene polymers (A1) and (A2) may be a known benzene-soluble aluminoxane or the benzene-insoluble organoaluminum oxy-compound disclosed in JP-A-2-78687/1990.

The above-mentioned known aluminoxane may be prepared, for example, by the following procedures:

- (1) a procedure for recovering an aluminoxane in the form of a hydrocarbon solution which comprises adding an organoaluminum compound such as trialkylaluminum to a suspension in a hydrocarbon medium of a compound containing adsorbed water, or a salt containing water of crystallization such as magnesium chloride hydrate, copper sulfate hydrate, aluminum sulfate hydrate, nickel sulfate hydrate and cerium chloride hydrate, and reacting the organoaluminum compound;
- (2) a procedure for recovering an aluminoxane in the form of a hydrocarbon solution which comprises reacting water, ice or steam directly with an organoaluminum compound such as trialkylaluminum in a solvent such as benzene, toluene, ethyl ether and tetrahydrofuran; and
- (3) a procedure for recovering an aluminoxane which comprises reacting an organotin oxide such as dimethyltin oxide and dibutyltin oxide with an organoaluminum compound such as trialkylaluminum in a solvent such as decane, benzene or toluene.

Moreover, the aluminoxane may contain a small amount of an organometal component. Furthermore, the solvent or unreacted organoaluminum compound may be removed from the above-mentioned recovered aluminoxane-containing solution, by distillation, and the aluminoxane may be redissolved in a solvent.

Concrete examples of the organoaluminum compound used for the preparation of the aluminoxane include

trialkylaluminum such as trimethylaluminum, triethylaluminum, tripropylaluminum, triisopropylaluminum, tri-n-butylaluminum, triisobutylaluminum, tri-sec-butylaluminum, tri-tert-butylaluminum, tri-pentylaluminum, trihexylaluminum, tri-octylaluminum and tridecylaluminum;

tricycloalkylaluminums such as tricyclohexylaluminum and tricyclooctylaluminum;

dialkylaluminum halides such as dimethylaluminum chloride, diethylaluminum chloride, diethylaluminum bromide and diisobutylaluminum chloride;

dialkylaluminum hydrides such as diethylaluminum hydride and diisobutylaluminum hydride;

dialkylaluminum alkoxides such as dimethylaluminum methoxide and diethylaluminum ethoxide; and

dialkylaluminum aryloxides such as diethylaluminum phenoxide.

Of these compounds, trialkylaluminum and tricyclo-alkylaluminum are preferable, and trimethylaluminum is particularly preferable.

Furthermore, there may also be used as the organoaluminum compound isoprenylaluminum represented by the general formula



wherein x, y and z are each a positive number, and  $z \geq 2x$ .

The organoaluminum compounds mentioned above may be used either singly or in combination.

Solvents used for the solutions of the aluminoxane include aromatic hydrocarbons such as benzene, toluene, xylene, cumene and cymene; aliphatic hydrocarbons such as pentane, hexane, heptane, octane, decane, dodecane, hexadecane and octadecane; alicyclic hydrocarbons such as cyclopentane, cyclohexane, cyclooctane and methylcyclopentane; petroleum fractions such as gasoline, kerosene and gas oil; and halogenated compounds derived from the above-mentioned aromatic hydrocarbons, aliphatic hydrocarbons and alicyclic hydrocarbons, especially chlorinated and brominated hydrocarbons. In addition, there may also be used ethers such as ethyl ether and tetrahydrofuran. Of these solvents as exemplified above, aromatic hydrocarbons or aliphatic hydrocarbons are particularly preferred.

As the compound (c) which reacts with the aforesaid transition metal compound (a) to form an ion pair and which is used for forming the olefin polymerization catalyst (1) employable for the preparation of the propylene polymers (A1) and (A2), there can be mentioned Lewis acids, ionic compounds and carborane compounds described in JP-A-1-501950/1989, JP-A-1-502036/1989, JP-A-3-179005/1992, JP-A-3-179006/1992, JP-A-3-207703/1992 and JP-A-3-207704/1992, and U.S. Patent Application No. 547718 (now US-A-5,321,106).

Examples of the Lewis acid include triphenylboron, tris(4-fluorophenyl)boron, tris(p-tolyl)boron, tris(o-tolyl)boron, tris(3,5-dimethylphenyl)boron, tris(pentafluorophenyl)boron,  $MgCl_2$ ,  $Al_2O_3$  and  $SiO_2-Al_2O_3$ .

Examples of the ionic compounds include triphenylcarbeniumtetrakis(pentafluorophenyl)borate, tri-n-butylammoniumtetrakis(pentafluorophenyl)borate, N,N-dimethylaniliniumtetrakis(pentafluorophenyl)borate and ferroceniumtetrakis(pentafluorophenyl)borate.

Examples of the carborane compounds include dodecaborane, 1-carbaundecaborane, bis-n-butylammonium (1-carbadodeca)borate, tri-n-butylammonium(7,8-dicarbaundeca)borate and tri-n-butylammonium(tridecahydride-7-carbaundeca)borate..

The compound (c) can be used in combination of two or more.

The olefin polymerization catalyst (1) is formed from the transition metal compound (a) and at least one of an organoaluminum oxy-compound (b) and a compound (c). However, the catalyst (1) may further contain an organoaluminum compound (j), if necessary, together with the above components.

The organoaluminum compound (j) is, for example, an organoaluminum compound of formula (II):



wherein  $R^9$  is a hydrocarbon group of 1 to 12 carbon atoms, X is a halogen atom, and n is 1 to 3.

In formula (II),  $R^9$  is a hydrocarbon group of 1 to 12 carbon atoms, for example, an alkyl group, a cycloalkyl group or an aryl group. Examples of those groups include methyl, ethyl, n-propyl, isopropyl, isobutyl, pentyl, hexyl, octyl, cyclopentyl, cyclohexyl, phenyl and tolyl.

Examples of the organoaluminum compounds (j) include:

trialkylaluminums, such as trimethylaluminum, triethylaluminum, triisopropylaluminum, triisobutylaluminum, triocetylaluminum, tri(2-ethylhexyl)aluminum and tridecylaluminum;  
alkenylaluminums, such as isoprenylaluminum;  
dialkylaluminum halides, such as dimethylaluminum chloride, diethylaluminum chloride, diisopropylaluminum chloride, diisobutylaluminum chloride and dimethylaluminum bromide;  
alkylaluminum sesquihalides, such as methylaluminum sesquichloride, ethylaluminum sesquichloride, isopropylaluminum sesquichloride, butylaluminum sesquichloride and ethylaluminum sesquibromide;  
alkylaluminum dihalides, such as methylaluminum dichloride, ethylaluminum dichloride, isopropylaluminum dichloride and ethylaluminum dibromide; and  
alkylaluminum hydrides, such as diethylaluminum hydride and diisobutylaluminum hydride.

Also employable as the organoaluminum compound (j) is a compound of formula (III):



wherein  $R^9$  is the same as above, L is  $-OR^{10}$  group,  $-OSiR^{11}_3$  group,  $-OAlR^{12}_2$  group,  $-NR^{13}_2$  group,  $-SiR^{14}_3$  group or  $-N(R^{15})AlR^{16}_2$  group; n is 1 or 2;  $R^{10}$ ,  $R^{11}$ ,  $R^{12}$  and  $R^{16}$  are each, for example methyl, ethyl, isopropyl, isobutyl, cyclohexyl or phenyl;  $R^{13}$  is, for example, hydrogen, methyl, ethyl, isopropyl, phenyl or trimethylsilyl; and  $R^{14}$  and  $R^{15}$  are each, for example, methyl or ethyl.

Of such organoaluminum compounds, preferred are compounds of formula  $R^9_n Al(OAlR^{10}_2)_{3-n}$ , for example,  $Et_2AlOAlEt_2$ , and  $(iso-Bu)_2AlOAl(iso-Bu)_2$ .

Of the organoaluminum compounds of formulae (II) and (III), preferred are compounds of formula  $R^9_n Al$ , and particularly preferred are compounds of formula  $R^9_n Al$  wherein  $R^9$  is an isoalkyl group.

The olefin polymerization catalyst (1) can be prepared by mixing the transition metal compound (a) [component (a)] and the organoaluminum oxy-compound (b) [component (b)] (or the compound (c) [component (c)]), and if desired, the organoaluminum compound (j) [component (j)] in an inert hydrocarbon solvent or an olefin solvent.

Examples of the inert hydrocarbon solvents include:

aliphatic hydrocarbons, such as propane, butane, pentane, hexane, heptane, octane, decane, dodecane and kerosine;  
alicyclic hydrocarbons, such as cyclopentane, cyclohexane and methylcyclopentane;  
aromatic hydrocarbons, such as benzene, toluene and xylene;  
halogenated hydrocarbons, such as ethylene chloride, chlorobenzene and dichloromethane; and  
mixtures of the above hydrocarbons.

In the preparation of the olefin polymerization catalyst (1), each component may be mixed in any order, but preferably they are mixed in the following manner:



component (b) [or the component (c)] is mixed with component (a);  
 component (b) is mixed with component (j), and the resulting mixture is then mixed with component (a);  
 component (a) is mixed with component (b) [or component (c)], and the resulting mixture is then mixed with component (j); or  
 component (a) is mixed with component (j), and the resulting mixture is then mixed with component (b) [or the component (c)].

In the mixing of each component, the atomic ratio (Al/transition metal) of the aluminum in component (b) to the transition metal in component (a) is usually 10 to 10,000, preferably 20 to 5,000; and the concentration of component (a) is about  $10^{-8}$  to  $10^{-1}$  mol/l-solvent, preferably  $10^{-7}$  to  $5 \times 10^{-2}$  mol/l-solvent.

When component (c) is used, the molar ratio [component (a)/component (c)] of component (a) to component (c) is usually 0.01 to 10, preferably 0.1 to 5; and the concentration of component (a) is about  $10^{-8}$  to  $10^{-1}$  mol/l-solvent, preferably  $10^{-7}$  to  $5 \times 10^{-2}$  mol/l-solvent.

When component (j) is used, the atomic ratio (Al/ $Al_b$ ) of the aluminum atoms ( $Al_j$ ) in component (j) to the aluminum atoms ( $Al_b$ ) in component (b) is usually 0.02 to 20, preferably 0.2 to 10.

The above-mentioned catalyst components may be mixed in a polymerizer. Otherwise, a mixture of the components prepared beforehand may be fed to a polymerizer.

If the components are mixed beforehand, the mixing temperature is usually -50 to 150 °C, preferably -20 to 120 °C; and the contact time is 1 to 1,000 minutes, preferably 5 to 600 minutes. The mixing temperature may be varied while the components are mixed and contacted with each other.

The olefin polymerization catalyst (1) may be a solid olefin polymerization catalyst in which at least one of component (a), component (b) [or component (c)] and component (j) is supported on an granular or particulate inorganic or organic solid carrier.

The inorganic carrier is preferably a porous oxide, for example,  $SiO_2$  or  $Al_2O_3$ .

Examples of the granular or particulate solid organic compounds include polymers or copolymers produced mainly from  $\alpha$ -olefins such as ethylene, propylene and 1-butene or styrene.

The olefin polymerization catalyst (1) may be a prepolymerized catalyst for olefin polymerization formed from the particulate carrier, component (a), component (b) [or component (c)] and an olefin polymer produced by the prepolymerization, and if desired, component (j).

The olefin used for the prepolymerization includes propylene, ethylene and 1-butene. Further, a mixture of these olefins and another olefin may also be employed.

In addition to the above components, the olefin polymerization catalyst (1) may contain other components which are useful for the olefin polymerization, for example, water as a catalyst component.

The propylene polymer (A1) and the propylene polymer (A2) can be prepared by polymerizing propylene in the presence of the olefin polymerization catalyst (1). In the polymerization of propylene, monomers such as ethylene and  $\alpha$ -olefins of 4 to 20 carbon atoms (e.g., 1-butene, 1-pentene, 1-hexene, 4-methyl-1-pentene, 1-octene, 1-decene, 1-dodecene, 1-tetradecene, 1-hexadecene, 1-octadecene and 1-eicosene) may be used in amounts of not more than 0.1 mol.

The polymerization may be carried out by either a liquid phase polymerization process such as a suspension polymerization process and a solution polymerization process, or a gas phase polymerization process.

In the liquid phase polymerization process, the same inert hydrocarbon solvent as used in the preparation of the catalyst described before can be used, or propylene can also be used as a solvent.

In the suspension polymerization process, the temperature for polymerizing propylene is usually -50 to 100 °C, preferably 0 to 90 °C. In the solution polymerization process, the polymerization temperature is usually 0 to 250 °C, preferably 20 to 200 °C. In the gas phase polymerization process, the polymerization temperature is usually 0 to 120 °C, preferably 20 to 100 °C. The polymerization pressure is usually atmospheric pressure to 100 kg/cm<sup>2</sup>, preferably atmospheric pressure to 50 kg/cm<sup>2</sup>. The polymerization reaction may be carried out either batchwise, semi-continuously or continuously. Further, it is also possible to conduct the polymerization in two or more steps having different reaction conditions.

The molecular weight of the resulting propylene polymer can be regulated by allowing hydrogen to exist in the polymerization system or by varying the polymerization temperature and the polymerization pressure.

#### The second propylene polymer composition.

##### Propylene polymer (A3)

The propylene polymer (A3) constituting the second propylene polymer composition is a propylene homopolymer or copolymer obtained by the use of an olefin polymerization catalyst comprising a solid titanium catalyst component

(d) and an organometallic compound catalyst component (e), both components being described later.

The propylene polymer (A3) has an MFR, as measured at 230 °C under a load of 2.16 kg, of 0.01 to 30 g/10 min, preferably 0.5 to 5 g/10 min, and Mw/Mn, as measured by GPC, of 4 to 15, preferably 4 to 8.

Further, the propylene polymer (A3) is desirably has an intrinsic viscosity  $[\eta]$  of 1.7 to 5.0 dl/g, preferably 2.2 to 3.5 dl/g, a weight-average molecular weight of  $15 \times 10^4$  to  $100 \times 10^4$ , preferably  $25 \times 10^4$  to  $50 \times 10^4$ , a crystallinity, as measured by X-ray diffractometry, of not less than 55 %, preferably not less than 60 %, and a boiling heptane extraction residue proportion (I.I.) of not less than 90 %, preferably not less than 93 %.

The propylene polymer (A3) may contain constituent units derived from monomers other than propylene, which are exemplified for the propylene polymer (A1), in an amount of not more than 5 % by mol.

#### Propylene polymer (A2)

The propylene polymer (A2) constituting the second propylene polymer composition is identical with the propylene polymer (A2) constituting the first propylene polymer composition.

#### Propylene polymer composition

The second propylene polymer composition comprises the propylene polymer (A3) and the propylene polymer (A2). In this composition, the propylene polymer (A3) is contained in an amount of 10 to 90 % by weight, preferably 30 to 70 % by weight; and the propylene polymer (A2) is contained in an amount of 10 to 90 % by weight, preferably 30 to 70 % by weight. The ratio  $[(A2)/(A3)]$  of the MFR of the propylene polymer (A2) to the MFR of the propylene polymer (A3) is desirably not less than 30, preferably 40 to 100.

The second propylene polymer composition desirably has an MFR, as measured at 230 °C under a load of 2.16 kg, of 1 to 100 g/10 min, preferably 5 to 50 g/10 min. In this composition, Mw/Mn of all the propylene components for constituting the composition is desirably 5 to 15.

The density of the second propylene polymer composition is desirably 0.89 to 0.92 g/cm<sup>3</sup>, preferably 0.90 to 0.92 g/cm<sup>3</sup>.

The heat distortion temperature (HDT) is desirably not lower than 100 °C, preferably 110 to 150 °C.

The flexural modulus (FM) is desirably 14,000 to 21,000 kg/cm<sup>2</sup>, preferably 16,000 to 20,000 kg/cm<sup>2</sup>.

The Izod impact strength (IZ) at 23 °C is desirably 2 to 4 kg-cm/cm, preferably 2 to 3 kg-cm/cm.

The tensile elongation at break (EL) is desirably 100 to 500 %, preferably 200 to 400 %.

The second propylene polymer composition may contain, if necessary, additives which may be added to the first propylene polymer composition, with the proviso that the object of the invention is not marred.

The second propylene polymer composition can be prepared by known processes. For example, the composition can be prepared in accordance with processes (1) to (4) described for the first propylene polymer composition, using the propylene polymer (A3), the propylene polymer (A2) and if desired other components which may be optionally added.

The second propylene polymer composition as mentioned above has not only excellent heat resistance, rigidity and tensile elongation at break but also excellent moldability.

Next, the olefin polymerization catalyst used for preparing the propylene polymer (A3) and the process for preparing the propylene polymer (A3) are described.

The propylene polymer (A3) can be prepared by polymerizing propylene in the presence of an olefin polymerization catalyst [olefin polymerization catalyst (2)] comprising:

(d) a solid titanium catalyst component, and

(e) an organometallic compound catalyst component.

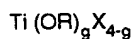
Fig. 2 illustrates the steps of a process for preparing the olefin polymerization catalyst which is used for the preparation of the propylene polymer (A3).

As the solid titanium catalyst component (d), solid titanium catalyst components containing titanium, magnesium and halogen, and, if desired, an electron donor (k), can be used.

The solid titanium catalyst component (d) can be prepared by, for example, bringing a titanium compound, a magnesium compound and an optional electron donor (k) into contact with each other.

The titanium compounds used in the preparation of the solid titanium catalyst component (d) include, for example, tetravalent titanium compounds or trivalent titanium compounds.

The tetravalent titanium compounds include compounds of formula:



wherein R is a hydrocarbon group, X is a halogen atom, and g is a number such that  $0 \leq g \leq 4$ .

Of these compounds, preferred are titanium tetrahalides, and particularly preferred is titanium tetrachloride. These titanium compounds may be used singly or in combination. Further, they may be diluted in hydrocarbon compounds or halogenated hydrocarbon compounds.

The trivalent titanium compound is, for example, titanium trichloride.

The magnesium compound used for preparing the solid titanium catalyst component (d) includes a magnesium compound having reduction properties and a magnesium compound having no reduction properties.

The magnesium compounds having reduction properties include organo-magnesium compounds of formula:



wherein n is a number such that  $0 \leq n < 2$ , R is hydrogen, an alkyl group of 1 to 20 carbon atoms, aryl group or cycloalkyl group (when n is 0, two of R are the same or different), and a hydrocarbon group.

Concrete examples of the magnesium compound having reduction properties include dialkylmagnesium compounds, alkylmagnesium halides, alkylmagnesium alkoxides and butylmagnesium hydride.

Concrete examples of the magnesium compound having no reduction properties include magnesium halide such as magnesium chloride, magnesium bromide, magnesium iodide and magnesium fluoride; alkoxymagnesium halide; aryloxymagnesium halide; alkoxymagnesium; aryloxymagnesium; and manesium carboxylate. Further, magnesium metal or hydrogenated magnesium may also be used.

These magnesium compounds having no reduction properties may be those derived from the above-mentioned magnesium compounds having reduction properties or those derived during the catalyst component preparation stage. In order to derive the magnesium compound having no reduction properties from the magnesium compound having reduction properties, the magnesium compound having reduction properties is brought into contact with a polysiloxane compound, a halogen-containing silane compound, a halogen-containing aluminum compound, an ester, an alcohol, halogen-containing compound or a compound having an OH-group or an active carbon-oxygen bond.

The magnesium compounds may be used singly or in combination of two, and in a liquid state or solid state. When the magnesium compound is solid, the compound can be brought into liquid state by using electron donors which are the same as those described later, such as alcohols, carboxylic acids, aldehydes, amines or metal acid esters.

In the preparation of the solid titanium catalyst component (d), an electron donor (k) is preferably used. Examples of the electron donor (k) include:

oxygen-containing electron donors such as alcohols, phenols, ketones, aldehydes, carboxylic acids, organic acid halides, esters of organic acids or inorganic acids, ethers, diethers, acid amides, acid anhydrides and alkoxysilanes, and

nitrogen-containing donors such as an ammonia, amines, nitriles, pyridines and isocyanates.

The solid titanium catalyst component (d) is prepared by bringing the aforementioned titanium compound, magnesium compound and the optional electron donor (k) into contact with each other.

Though the processes for preparing the solid titanium catalyst component (d) are no way limited, examples of such processes using the tetravalent titanium compound are briefly described below:

(1) A process comprising bringing a solution consisting of a magnesium compound, an electron donor (k) and a hydrocarbon solvent into contact with an organometallic compound, after or simultaneously with precipitating a solid by bringing the solution into contact with a titanium compound.

(2) A process comprising bringing a complex composed of a magnesium compound and an electron donor (k) into contact with an organometallic compound, and then bringing the reaction product into contact with a titanium compound.

(3) A process comprising bringing a product obtained by the contact of an inorganic carrier and an organic magnesium compound into contact with a titanium compound. In this case, the above product may be beforehand brought into contact with a halogen-containing compound, an electron donor (k) and/or an organometallic compound.

(4) A process comprising obtaining an inorganic or organic carrier on which a magnesium compound is supported from a mixture of an inorganic or organic carrier and a solution containing a magnesium compound and an electron donor (k) (and further a hydrocarbon solvent in some cases), and then bringing the obtained carrier into contact

with a titanium compound.

(5) A process comprising bringing a solution containing a magnesium compound, a titanium compound and an electron donor (k) (and further a hydrocarbon solvent in some cases) into contact with an inorganic or organic carrier to obtain a solid titanium catalyst component on which magnesium and titanium are supported.

(6) A process comprising bringing a liquid organic magnesium compound into contact with a halogen-containing titanium compound.

(7) A process comprising bringing a liquid organic magnesium compound into contact with a halogen-containing compound, and then bringing the product thus obtained into contact with a titanium compound.

(8) A process comprising bringing an alkoxy group-containing magnesium compound into contact with a halogen-containing titanium compound.

(9) A process comprising bringing a complex composed of an alkoxy group-containing magnesium compound and an electron donor (k) into contact with a titanium compound.

(10) A process comprising bringing a complex composed of an alkoxy group-containing magnesium compound and an electron donor (k) into contact with an organometallic compound, and then bringing the product thus obtained into contact with a titanium compound.

(11) A process comprising bringing a magnesium compound, an electron donor (k) and a titanium compound into contact with each other in an optional order. In this reaction, each component may be pretreated with an electron donor (k) and/or a reaction assistant such as an organometallic compound or a halogen-containing silicon compound. In this case, an electron donor is preferably used at least once.

(12) A process comprising bringing a liquid magnesium compound not having reducing ability into contact with a liquid titanium compound, if necessary in the presence of an electron donor (k), to precipitate a solid magnesium/titanium complex compound.

(13) A process comprising further bringing the reaction product obtained in the above process (12) into contact with a titanium compound.

(14) A process comprising further bringing the reaction product obtained in the above process (11) or (12) into contact with an electron donor (k) and a titanium compound.

(15) A process comprising pulverizing a magnesium compound and a titanium compound (and if necessary an electron donor (k)) to obtain a solid product, and treating the solid product with either a halogen, a halogen compound or aromatic hydrocarbon. This process may include a step of pulverizing only a magnesium compound, a step of pulverizing a complex compound composed of a magnesium compound and an electron donor (k), or a step of pulverizing a magnesium compound and a titanium compound. Further, after the pulverization, the solid product may, for example, be subjected to a pretreatment with a reaction assistant and then subjected to a treatment with a halogen. Examples of the reaction assistants include an organometallic compound and a halogen-containing silicon compound.

(16) A process comprising pulverizing a magnesium compound, and then bringing the pulverized magnesium compound into contact with a titanium compound. In this case, an electron donor (k) or a reaction assistant may be used in the pulverization stage and/or the contacting reaction stage.

(17) A process comprising treating the compound obtained in any of the above processes (11) to (16) with a halogen, a halogen compound or aromatic hydrocarbon.

(18) A process comprising bringing the reaction product obtained by the contact of a metal oxide, an organic magnesium compound and a halogen-containing compound into contact with a titanium compound and if necessary an electron donor (k).

(19) A process comprising bringing a magnesium compound such as a magnesium salt of organic acid, alkoxy-magnesium or aryloxymagnesium into contact with a titanium compound and/or halogen-containing hydrocarbon and if necessary an electron donor (k).

(20) A process comprising bringing a hydrocarbon solution containing at least a magnesium compound and alkoxytitanium into contact with a titanium compound and/or an electron donor (k). In this case, a halogen-containing compound such as a halogen-containing silicon compound may be further brought into contact therewith, if necessary.

(21) A process comprising bringing a liquid magnesium compound not having reducing ability into contact with an organometallic compound so as to precipitate a solid magnesium/metal (aluminum) complex compound, and then bringing the resulting compound into contact with an electron donor (k) and a titanium compound.

The preparation of the solid titanium catalyst component (d) is usually conducted at a temperature of -70 to 200 °C, preferably -50 to 150 °C.

The solid titanium catalyst component (d) thus obtained contains titanium, magnesium, halogen and optionally an electron donor.

In the solid titanium catalyst component (d), the ratio of halogen/titanium (atomic ratio) is about 2 to 200, preferably

about 4 to 90, and the ratio of magnesium/titanium (atomic ratio) is 1 to 100, preferably 2 to 50.

Further, the electron donor (k) is contained in a ratio of electron donor (k)/titanium (molar ratio) of about 0.01 to 100, preferably about 0.05 to 50.

Details of the processes for preparation of the solid titanium catalyst component (d), are given in the following publications:

JP-B-46-34092/1971, JP-B-53-46799/1978, JP-B-60-3323/1985, JP-B-63-54289/1988, JP-A-1-261404/1989, JP-A-1-261407/1989, JP-B-47-41676/1972, JP-B-47-46269/1972, JP-B-19794/1973, JP-A-60-262803/1985, JP-A-59-147004/1984, JP-A-59-149911/1984, JP-A-1-201308/1989, JP-A-61-151211/1986, JP-A-53-58495/1978, JP-A-53-87990/1978, JP-A-59-206413/1984, JP-A-58-206613/1983, JP-A-58-125706/1983, JP-A-63-68606/1988, JP-A-63-69806/1988, JP-A-60-81210/1985, JP-A-61-40306/1986, JP-A-51-281189/1976, JP-A-50-126590/1975, JP-A-51-92885/1976, JP-B-57-45244/1982, JP-B-57-26613/1982, JP-B-61-5483/1986, JP-A-56-811/1981, JP-B-60-37804/1985, JP-B-59-50246/1984, JP-A-58-83006/1983, JP-A-48-16986/1973, JP-A-49-65999/1974, JP-A-49-86482/1974, JP-B-56-39767/1981, JP-B-56-32322/1981, JP-A-55-29591/1980, JP-A-53-146292/1978, JP-A-57-63310/1982, JP-A-57-63311/1982, JP-A-57-63312/1982, JP-A-62-273206/1987, JP-A-63-69804/1988, JP-A-61-21109/1986, JP-A-63-264607/1988, JP-A-60-23404/1985, JP-A-60-44507/1985, JP-A-60-158204/1985, JP-A-61-55104/1986, JP-A-2-28201/1990, JP-A-58-196210/1983, JP-A-64-54005/1989, JP-A-59-149905/1984, JP-A-61-145206/1986, JP-A-63-302/1988, JP-A-63-225605/1988, JP-A-64-69610, JP-A-1-168707/1989, JP-A-62-104810/1987, JP-A-62-104811/1987, JP-A-62-104812/1987 and JP-A-62-104813/1987.

In the present invention, a conventional titanium trichloride type catalyst component may also be used as the solid titanium catalyst component (d).

The above mentioned titanium trichloride is exemplified as the titanium trichloride type catalyst component. The titanium trichloride is used together with the aforementioned electron donor (k) and/or the tetravalent titanium compound, or after the contact with them.

Details of the processes for preparation of the titanium trichloride type catalyst component are given in the following publications:

JP-A-63-17274/1988, JP-A-64-38409/1989, JP-A-56-34711/1981, JP-A-61-287904/1986, JP-A-63-75007/1988, JP-A-63-83106/1988, JP-A-59-13630/1984, JP-A-63-108008/1988, JP-A-63-27508/1988, JP-A-57-70110/1982, JP-A-58-219207/1983, JP-A-1-144405/1989 and JP-A-1-292011/1989.

An example of the titanium trichloride type catalyst component includes titanium trichloride. As the titanium trichloride, there can be preferably used a titanium trichloride which is obtained by, for example, reducing the tetravalent titanium by contacting with hydrogen, metal such as magnesium metal, aluminum metal or titanium metal, or an organic metal compound such as organomagnesium compound, organoaluminum compound or organozinc compound. The titanium trichloride is used together with the aforementioned electron donor (k) and/or the tetravalent titanium compound, or after the contact with them.

Examples of the organometallic compound catalyst component (e) which forms the olefin polymerization catalyst (2) used in the polymerization of the propylene polymer (A3) include (e-1) an organoaluminum compound, (e-2) a complex alkyl compound of aluminum with a Group I metal of the periodic table and (e-3) a organometallic compound of Group II metal of the periodic table.

Examples of the organoaluminum compound (e-1) are the same as those given for the organoaluminum compound (i).

Examples of the complex alkyl compound of aluminum with Group I metals of the periodic table (e-2) are those of the formula:



wherein  $M^1$  is Li, Na or K and  $R^j$  is a hydrocarbon group of 1 to 15 carbon atoms.

Examples of the organometallic compound of Group II metal of the periodic table (e-3) are those of the formula:



wherein  $R^k$  and  $R^l$  are a hydrocarbon group of 1 to 15 carbon atoms or a halogen, and they are the same or different with the proviso that they are not both a halogen, and  $M^2$  is Mg, Zn or Cd.

These compounds may be used in combination of 2 or more.

In the preparation of the propylene polymer (A3), the aforesaid organoaluminum oxy-compound (b) can be also employed.

The propylene polymer (A3) can be prepared by polymerizing propylene in the presence of the olefin polymerization

catalyst (2).

The olefin polymerization catalyst (2) may be a prepolymerized catalyst obtained by prepolymerizing the catalyst comprising the solid titanium catalyst component (d) and the organometallic compound catalyst component (e) with an olefin.

Examples of the olefins used for the prepolymerization include  $\alpha$ -olefins of 2 to 20 carbon atoms. Of these, propylene is preferred.

In the prepolymerization, the same electron donor as the aforementioned electron donor (k) or the following electron donor (l) may be used if necessary, in addition to the catalyst component (d) and the catalyst component (e).

The electron donor (l) is, for example, an organosilicon compound of formula:



wherein R and R' are each a hydrocarbon group, and  $0 < n < 4$ .

These organosilicon compounds may be used in combination of two of more kinds.

Also employable as the electron donor (l) are:

nitrogen-containing electron donors, such as 2,6-substituted piperidines, 2,5-substituted piperidines, substituted methylenediamines and substituted imidazolidines;

phosphorus-containing electron donors, such as phosphites; and

oxygen-containing electron donors, such as 2,6-substituted tetrahydropyrans and 2,5-substituted tetrahydropyrans.

In the prepolymerization, the olefin is desirably polymerized in an amount of 0.01 to 2,000 g, preferably 0.03 to 1,000 g, particularly preferably 0.05 to 200 g, per 1 g of the solid titanium catalyst component (d).

The prepolymerized catalyst prepared as above is usually obtained in the form of a suspension. In the subsequent polymerization step, such prepolymerized catalyst may be used in the form of the suspension. Otherwise, the prepolymerized catalyst produced may be separated from the suspension before use.

When the prepolymerized catalyst is used for the polymerization to prepare the propylene polymer (A3), the organometallic compound catalyst component (e) is preferably used in combination with the prepolymerized catalyst.

The propylene polymer (A3) can be prepared by polymerizing propylene in the presence of the olefin polymerization catalyst (2). In the polymerization of propylene, ethylene and monomers which are exemplified for the propylene polymer (A1) and the propylene polymer (A2), such as  $\alpha$ -olefins of 4 to 20 carbon atoms, may be used in amounts of not more than 0.1 mol per 1 mol of propylene.

The propylene polymer (A3) may be prepared by either a liquid phase polymerization process such as a solution polymerization process and a suspension polymerization process, or a gas phase polymerization process.

When the polymerization is a suspension polymerization, polyene compounds and olefins which are liquid at reaction temperatures and/or the same inert solvents as used for the aforementioned prepolymerization can be used as the reaction solvent.

The olefin polymerization catalyst (2) used for the polymerization is generally used in the following amounts though the amounts vary depending upon the kinds:

The solid titanium catalyst component (d) (including the prepolymerized catalyst) is usually used in an amount of about 0.001 to 100 mmol, preferably about 0.005 to 20 mmol, in terms of the titanium atoms in the solid titanium catalyst component (d) or the prepolymerized catalyst, based on 1 liter of the polymerization volume.

The organometallic compound catalyst component (e) is used in such an amount that the amount of the metal atoms in said catalyst component (e) is usually about 1 to 2,000 mol, preferably about 5 to 500 mol, based on 1 mol of the titanium atoms in the solid titanium catalyst component (d) or the prepolymerized catalyst.

The electron donors (k) and (l) may be also employed in addition to the catalyst components (d) and component (e). When the electron donor is used, the amount of the electron donor is usually about 0.001 to 10 mol, preferably 0.01 to 5 mol, based on 1 mol of the metal atoms in the organometallic compound catalyst component (e).

The olefin polymerization catalyst (2) may contain components other than the above-mentioned components, which are useful for the olefin polymerization.

The molecular weight of the resulting polymer may be regulated if hydrogen is used in the polymerization, and thereby a polymer having a high melt flow rate can be obtained.

The polymerization is generally carried out under the following conditions. The polymerization temperature is about -40 to 300 °C, preferably about -20 to 150 °C, and the polymerization pressure is atmospheric pressure to 100 kg/cm<sup>2</sup>, preferably about 2 to 50 kg/cm<sup>2</sup>.

The polymerization can be carried out either batchwise, semi-continuously or continuously. Further, the polymer-

ization can be conducted in two or more steps, and in this case, the reaction conditions may be the same as or different from each other.

#### The third propylene polymer composition

##### Propylene polymer (A3)

The propylene polymer (A3) constituting the third propylene polymer composition is identical with the propylene polymer (A3) constituting the above-mentioned second propylene polymer composition.

##### Propylene polymer (A2)

The propylene polymer (A2) constituting the third propylene polymer composition is identical with the propylene polymer (A2) constituting the above-mentioned first propylene polymer composition.

##### Soft polymer (B)

The soft polymer (B) constituting the third propylene polymer composition is identical with the soft polymer (B) constituting the above-mentioned first propylene polymer composition.

#### Propylene polymer composition

The third propylene polymer composition comprises the propylene polymer (A3), the propylene polymer (A2) and the soft polymer (B). In this composition, the propylene polymer (A3) is contained in an amount of 10 to 90 parts by weight, preferably 30 to 70 parts by weight; the propylene polymer (A2) is contained in an amount of 10 to 90 parts by weight, preferably 30 to 70 parts by weight; and the soft polymer (B) is contained in an amount of 3 to 30 parts by weight, preferably 10 to 25 parts by weight. The ratio [(A2)/(A3)] of the MFR of the propylene polymer (A2) to the MFR of the propylene polymer (A3) is desirably not less than 30, preferably 40 to 100.

The third propylene polymer composition desirably has an MFR, as measured at 230 °C under a load of 2.16 kg, of 1 to 100 g/10 min, preferably 5 to 50 g/10 min. In this composition, Mw/Mn of all the propylene components for constituting the composition is desirably 5 to 15.

The density of the third propylene polymer composition desirably is 0.88 to 0.92 g/cm<sup>3</sup>, preferably 0.89 to 0.92 g/cm<sup>3</sup>.

The heat distortion temperature (HDT) is desirably to be not lower than 85 °C, preferably 95 to 140 °C.

The flexural modulus (FM) is desirably 8,500 to 18,000 kg/cm<sup>2</sup>, preferably 9,000 to 15,000 kg/cm<sup>2</sup>.

The Izod impact strength (IZ) at 23 °C is desirably 10 to 50 kg-cm/cm, preferably 10 to 40 kg-cm/cm.

The tensile elongation at break (EL) is desirably 200 to 1,000 %, preferably 300 to 500 %.

The third propylene polymer composition may contain the aforesaid additives, if necessary, with the proviso that the object of the invention is not marred.

The third propylene polymer composition can be prepared by known processes. For example, the composition can be prepared in accordance with the processes (1) to (4) described for the first propylene polymer composition, using the propylene polymer (A3), the propylene polymer (A2), the soft polymer (B) and if desired other components which may be optionally added.

The propylene polymer compositions of the invention have excellent heat resistance, rigidity and tensile elongation at break.

#### EXAMPLES

The present invention is now described in more detail in the following Examples;  
In the present invention, the physical properties were measured by the following methods.

##### Intrinsic viscosity [ $\eta$ ]

The intrinsic viscosity [ $\eta$ ] was measured in decalin at 135 °C.

##### Melt flow rate (MFR)

The melt flow rate (MFR) was measured in accordance with ASTM D1238 under the following conditions.

Conditions: 230 °C, 2.16 kg

#### Flexural modulus (FM)

The flexural modulus (FM) was measured in accordance with ASTM D790 under the following conditions.

Size of specimen:

12.7 (width) × 6.4 (thickness) × 127 (length)

Span: 100 mm

Flexure rate: 2 mm/min

#### Izod impact strength (IZ)

The Izod impact strength (IZ) was measured in accordance with ASTM D256 under the following conditions.

Temperature: 23 °C, -30 °C

Size of specimen:

12.7 (width) × 6.4 (thickness) × 64 (length)

The specimen was mechanically notched.

#### Tensile elongation at break (EL)

The tensile elongation at break (EL) was measured in accordance with ASTM D638 under the following conditions.

Temperature: 23 °C

#### Heat distortion temperature (HDT)

The heat distortion temperature was measured in accordance with ASTM D648 under the following conditions.

Size of specimen:

12.7 (width) × 6.4 (thickness) × 127 (length)

#### Preparation Example

[Preparation of a propylene polymer (1)]

A catalyst component was prepared by mixing 0.0030 mmol (in terms of Zr atoms) of *rac*-dimethylsilylbis(2-methylindenyl)zirconium dichloride and 1.50 mmol of methylaluminoxane.

Into a 4-liter stainless steel autoclave thoroughly purged with nitrogen was introduced 1 liter of purified toluene, followed by stirring for 20 minutes in a propylene atmosphere. Then, the temperature of the reaction system was raised. When the temperature became 30 °C, 1.5 mmol of methylaluminoxane and the catalyst component prepared above were added to the system, thereby to perform polymerization for 1 hour at 40 °C under a propylene pressure of 3 kg/cm<sup>2</sup>-G. After the polymerization, the solvent was removed by filtration, and the resulting product was washed with methanol and dried in vacuo at 80 °C for 10 hours.

Thus, a polymer [propylene polymer (1)] was obtained in an amount of 146 g, and the polymerization activity was 48,700 g-PP/mmol-Zr. This polymer had  $[\eta]$  of 2.58 dl/g, MFR of 1.9 g/10 min, Mw of 339,000 and Mw/Mn of 2.03.

[Preparation of a propylene polymer (2)]

#### Preparation of a solid catalyst component

A 500-ml reactor thoroughly purged with nitrogen was charged with 25 g of silica (i.e., F-948 of Fuji Davison Co. having been dried at 200 °C for 6 hours in a stream of nitrogen) and 310 ml of toluene, and the temperature of the system was made 0 °C with stirring. To the system was dropwise added 90 ml of an organoaluminum oxy-compound (i.e., methylaluminoxane of Schering Co. having been diluted with toluene, 2.1 mol/l) over a period of 60 minutes in a nitrogen atmosphere. Then, the reaction was carried out at the same temperature for 30 minutes, successively at 90 °C for 4 hours. Thereafter, the reaction system was cooled by allowing it to stand. When the temperature became 60 °C, the supernatant liquid was removed by decantation, and the resulting reaction liquid was washed three times with 150 ml of toluene.

Thus, a solid catalyst component (C-1) containing 6.8 mmol of Al based on 1 g of silica was obtained.



Preparation of a prepolymerized catalyst component (C-2)

A 500-ml reactor thoroughly purged with nitrogen was charged with 320 ml of n-hexane. Then, to the reactor were added 40 mmol (in terms of Al atoms) of the solid catalyst component (C-1) obtained above and 0.04 mmol (in terms of Zr atoms) of rac-dimethylsilylbis(2-methylindenyl) zirconium dichloride, and the contents in the reactor were stirred for 10 minutes. Further, 1.2 mmol of triisobutylaluminum was added, followed by stirring for another 10 minutes. Then, propylene gas (13.4 l/hr) was passed through the reactor for 1 hour at 20 °C to perform prepolymerization of propylene. The supernatant liquid was removed by decantation, and the resulting product was washed three times with 150 ml of decane.

Thus, a prepolymerized catalyst component (C-2) in which Zr and Al were supported in amounts of 0.0042 mmol and 4.35 mmol, respectively, based on 1 g of the solid catalyst was obtained.

Polymerization

Into a 4-liter stainless steel autoclave thoroughly purged with nitrogen was introduced 1.5 liters of n-hexane, followed by stirring for 20 minutes in a propylene atmosphere. Then, the temperature of the reaction system was raised. When the temperature became 50 °C, 2.90 mmol of triisobutylaluminum, 0.0030 mmol (in terms of Zr atoms) of the prepolymerized catalyst component (C-2) prepared above and 150 ml of hydrogen were added to the system, thereby to perform polymerization for 2 hours at 60 °C under a propylene pressure of 7 kg/cm<sup>2</sup>-G. After the polymerization, the solvent was removed by filtration, and the resulting product was washed with methanol and dried in vacuo at 80 °C for 10 hours.

Thus, a polymer [propylene polymer (2)] was obtained in an amount of 304 g, and the polymerization activity was 101,000 g-PP/mmol-Zr. This polymer had  $[\eta]$  of 1.01 dl/g, MFR of 145 g/10 min and Mw/Mn of 3.78.

## [Preparation of a propylene polymer (3)]

Preparation of a prepolymerized catalyst component (C-3)

A 500-ml reactor thoroughly purged with nitrogen was charged with 350 ml of n-hexane. To the reactor were added 16 mmol (in terms of Al atoms) of the solid catalyst component (C-1) prepared above and 0.04 mmol (in terms of Zr atom) of rac-dimethylsilylbis(2-methylindenyl)zirconium dichloride, and the contents in the reactor were stirred for 10 minutes. Further, 1.2 mmol of triisobutylaluminum was added, followed by stirring for another 10 minutes. Then, propylene gas (13.4 l/hr) was passed through the reactor for 1 hour at 20 °C to perform prepolymerization of propylene. The supernatant liquid was removed by decantation, and the resulting product was washed three times with 150 ml of decane.

Thus, a prepolymerized catalyst component (C-3) in which Zr and Al were supported in amounts of 0.0011 mmol and 4.50 mmol, respectively, based on 1 g of the solid catalyst was obtained.

Polymerization

Into a 2-liter stainless steel autoclave thoroughly purged with nitrogen was introduced 750 ml of n-hexane, followed by stirring for 20 minutes in a propylene atmosphere. Then, the temperature of the reaction system was raised. When the temperature became 50 °C, 2.7 mmol of triisobutylaluminum and 0.045 mmol (in terms of Zr atom) of the prepolymerized catalyst component (C-3) prepared above were added to the system, thereby to perform polymerization for 1.5 hours at 60 °C under a propylene pressure of 7 kg/cm<sup>2</sup>-G. After the polymerization, the solvent was removed by filtration, and the resulting product was washed with methanol and dried in vacuo at 80 °C for 10 hours.

Thus, a polymer [propylene polymer (3)] was obtained in an amount of 403 g, and the polymerization activity was 89,600 g-PP/mmol-Zr. This polymer had  $[\eta]$  of 1.33 dl/g, MFR of 34 g/10 min and Mw/Mn of 2.93.

## [Preparation of a propylene polymer (4)]

Preparation of a solid titanium catalyst component

95.2 g of anhydrous magnesium chloride, 442 ml of decane and 390.6 g of 2-ethylhexyl alcohol were mixed and then heated at 130 °C for 2 hours to give a homogeneous solution. To the solution was added 21.3 g of phthalic anhydride, and they were further stirred at 130 °C for 1 hour to dissolve the phthalic anhydride in the homogeneous solution. After the resulting solution was cooled to room temperature, 75 ml of the solution was dropwise added to 200 ml of titanium tetrachloride kept at -20 °C over a period of 1 hour. After the addition was completed, the temperature

of the mixed solution was raised to 110 °C over a period of 4 hours. When the temperature of the solution reached 110 °C, 5.22 g of diisobutyl phthalate (DIBP) was added to the solution, followed by stirring at the same temperature for 2 hours. After the 2-hour reaction was completed, the solid portion was collected by hot filtration, and resuspended in 275 ml of titanium tetrachloride. The resulting suspension was again heated at 110 °C for 2 hours to perform reaction.

After the reaction was completed, the solid portion was collected again by hot filtration, and sufficiently washed with decane and hexane at 110 °C until any titanium compound liberated in the washing liquid was not detected. Through the above process, the solid titanium catalyst component was obtained in the form of a decane slurry, and a part of this decane slurry was dried for the purpose of examining the catalyst composition.

As a result, the solid titanium catalyst component had a composition comprising 2.4 % by weight of titanium, 60 % by weight of chlorine, 20 % by weight of magnesium and 13.0 % by weight of DIBP.

#### Preparation of a prepolymerized catalyst component (C-4)

A 400-ml four-necked glass reactor equipped with a stirrer was charged with 150 ml of purified hexane, 15 mmol of triethylaluminum, 3 mmol of dicyclopentylmethoxysilane (DCPMS) and 1.5 mmol (in terms of Ti atoms) of the solid titanium catalyst component prepared above in a nitrogen atmosphere. Then, to the reactor was fed propylene at 20 °C for 1 hour at a feed rate of 3.2 l/hr. After feeding of propylene was completed, the reactor was purged with nitrogen, and a washing operation consisting of removal of a supernatant liquid and addition of purified hexane was carried out twice. Then, the resulting product was resuspended in purified hexane, and all the resulting suspension was transferred into a catalyst bottle to obtain a prepolymerized catalyst component (C-4).

#### Polymerization

Into a 17-liter autoclave was introduced 4 kg of propylene at room temperature in a propylene atmosphere. To the autoclave was added 11 liters of hydrogen, and the temperature of the reaction system was raised to 60 °C. To system were further added 5 mmol of triethylaluminum, 5 mmol of DCPMS and 0.05 mmol (in terms of Ti atoms) of the prepolymerized catalyst component (C-4) prepared above, and the temperature of the system was further raised to 70 °C to perform polymerization reaction at the same temperature for 40 minutes. Immediately after the reaction was completed, a small amount of ethanol was added to the system to decompose the catalyst, thereafter the unreacted propylene and hydrogen were purged. Thus, a white powdery polymer was obtained. The white powdery polymer thus obtained was dried in vacuo at 80 °C for 10 hours.

The amount of the white powdery polymer [propylene polymer (4)] obtained after drying was 1,630 g, and therefore the polymerization activity was 32,600 g-PP/mmol-Ti. This polymer had a boiling heptane extraction residue proportion (I.I.) of 99.1 %,  $[\eta]$  of 3.0 dl/g, MFR of 1.2 g/10 min and  $M_w/M_n$  of 5.1.

#### [Preparation of a propylene polymer (5)]

The procedures of the polymerization and the post treatment for preparing the propylene polymer (4) were repeated except that the addition amount of hydrogen was varied to 150 liters.

The amount of the polymer [propylene polymer (5)] thus obtained was 2,030 g, and the polymerization activity corresponded to 40,600 g-PP/mmol-Ti. This polymer had  $[\eta]$  of 1.10 dl/g, MFR of 155 g/10 min,  $M_w/M_n$  of 4.9 and a boiling heptane extraction residue proportion (I.I.) of 97.0 %.

#### [Preparation of a propylene polymer (7)]

#### Synthesis of 3-(2-biphenyl)-2-ethylpropionic acid

To a 2-liter four-necked round flask (equipped with a stirrer, a Zimroth condenser, a dropping funnel and a thermometer) were fed 40.4 g (360 mmol) of potassium t-butoxide, 300 ml of toluene and 60 ml of N-methylpyrrolidone. Then, a solution obtained by dissolving 62.1 g (330 mmol) of diethyl ethylmalonate in 150 ml of toluene was dropwise added to the system while heating at 60 °C in a nitrogen atmosphere. After the addition was completed, the resulting mixture was reacted for 1 hour at the same temperature. Then, to the mixture was dropwise added at the same temperature a solution obtained by dissolving 60.8 g (300 mmol) of 2-phenylbenzyl bromide in 90 ml of toluene. After the addition was completed, the temperature of the system was elevated, and the reaction mixture was refluxed for 2 hours. The reaction mixture was poured in 600 ml of water, and adjusted to pH 1 by adding 2N-HCl. The organic phase was separated, and the aqueous phase was extracted three times with 200 ml of toluene. The whole organic phase was washed with a saturated salt solution until the organic phase became neutral, and dried with anhydrous  $\text{Na}_2\text{SO}_4$ . The solvent was concentrated under reduced pressure to obtain 110 g of an yellow-orange concentrated solution.

To a 2-liter four-necked round flask (equipped with a stirrer, a Zimroth condenser, a dropping funnel and a thermometer) were fed 202 g (3.06 mol) of potassium hydroxide and 480 ml of an aqueous solution of methanol (methanol/water = 4/1 (v/v)). Then, a solution obtained by dissolving the above-obtained concentrate in 150 ml of an aqueous solution of methanol (methanol/water = 4/1 (v/v)) was dropwise added at room temperature. After the addition, the temperature of the system was elevated, and the resulting mixture was refluxed for 4 hours. Then, the mixture was cooled to room temperature, and the precipitated solid was filtered. The product obtained by filtration was dissolved in water. The resulting solution was adjusted to pH 1 (acidic) by adding a sulfuric acid and extracted five times with 200 ml of methylene chloride. The whole organic phase was dried with anhydrous  $\text{Na}_2\text{SO}_4$ . The solvent was concentrated under reduced pressure to obtain 72.6 g of a white solid product.

To a 1-liter three-necked round flask (equipped with a stirrer, a Zimroth condenser and a thermometer) were fed 72.6 g of the above-obtained white solid, 168 ml of an acetic acid, 111 ml of water and 39.3 ml of a concentrated sulfuric acid, and the contents in the flask were refluxed for 6 hours in a nitrogen atmosphere. After the reaction was completed, the acetic acid was distilled off under reduced pressure, then to the resulting solution was added 150 ml of water, and the solution was extracted three times with 150 ml of methylene chloride. The whole organic phase was washed with 150 ml of a saturated salt solution, and dried with anhydrous  $\text{Na}_2\text{SO}_4$ . The solvent was distilled off under reduced pressure, and the residue was separated and purified by silica gel chromatography (developed with hexane/ethyl acetate (2/1  $\rightarrow$  1/1, by parts by volume)), to obtain 41.1 g of a white solid (yield: 54 %).

The physical properties of the product obtained are as follows.

FD-MS: 254 ( $\text{M}^+$ )

m.p.: 91.2 - 94.0 °C

NMR ( $\text{CDCl}_3$ , 90 MHz):

$\delta$  = 0.71 (t, J = 7.2 Hz, 3H,  $\text{CH}_3$ ); 1.16 - 1.58 (m, 2H); 2.32 (bquin, J = 7.0 Hz, 1H,

|  
-CH-;

2.61 - 2.99 (m, 2H); 6.89 - 7.47 (m, 9H)

IR (KBr disk): 1,696  $\text{cm}^{-1}$  ( $\nu_{\text{C=O}}$ )

#### Synthesis of 3-(2-biphenyl)-2-ethylpropionyl chloride

To a 300-ml three-necked round flask (equipped with a stirrer tip, a Zimroth condenser, a thermometer and a NaOH trap) were fed 39.9 g (157.2 mmol) of 3-(2-biphenyl)-2-ethylpropionic acid and 77.7 ml (1,065 mmol) of thionyl chloride, and the contents in the flask were refluxed for 2.5 hours in a nitrogen atmosphere. After the reaction was completed, the unreacted thionyl chloride was distilled off under reduced pressure to obtain 45.6 g of a coarse product of an yellow-orange liquid. This acid chloride was used for the next reaction without any further purification.

The physical properties of the product obtained are as follows.

IR (Neat): 1,786  $\text{cm}^{-1}$  ( $\nu_{\text{C=O}}$ )

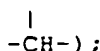
#### Synthesis of 4-ethyl-2-phenyl-1-indanone

To a 500-ml three-necked round flask (equipped with a stirrer, a Zimroth condenser, a dropping funnel, a thermometer and a NaOH trap) were fed 24.1 g (181 mmol) of anhydrous aluminum chloride and 150 ml of carbon disulfide. Then, a solution obtained by dissolving 45.6 g (52.4 mmol) of 3-(2-biphenyl)-2-ethylpropionyl chloride in 63 ml of carbon disulfide was dropwise added to the system while cooling with ice in a nitrogen atmosphere. After the addition was completed, the temperature in the flask was raised to room temperature to perform reaction for 1 hour. The reaction solution was poured in 600 ml of ice water to decompose the solution, and extracted twice with 300 ml of ether. The whole organic phase was successively washed with 300 ml of a saturated  $\text{NaHCO}_3$  solution and 300 ml of a saturated salt solution, and dried with anhydrous  $\text{Na}_2\text{SO}_4$ . The solvent was distilled off under reduced pressure, and the residue was separated and purified by silica gel chromatography (developed with hexane/ethyl acetate (10/1, by parts by volume)), to obtain 32.4 g of the aimed product as an yellow solid (yield: 88 %).

The physical properties of the product obtained are as follows.

NMR ( $\text{CDCl}_3$ , 90 MHz):

$\delta$  = 0.98 (t, J = 7.2 Hz, 3H,  $\text{CH}_3$ ); 1.60 - 2.20 (m, 2H); 2.42 - 2.82 (m, 1H,



2.80 (dd, J = 3.8 Hz, 16.5 Hz, 1H); 3.36 (dd, J = 7.6 Hz, 16.5 Hz, 1H); 7.09 - 7.91 (m, 8H)  
IR (Neat): 1,705 cm<sup>-1</sup> (ν<sub>C=O</sub>)

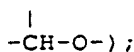
#### Synthesis of 2-ethyl-1-hydroxy-2-phenylindane

To a 500-ml three-necked round flask (equipped with a stirrer tip, a Zimroth condenser, a dropping funnel and a thermometer) were fed 2.55 g (67.8 mmol) of sodium boron hydride and 84 ml of ethanol. Then, a solution obtained by dissolving 31.8 g (135.3 mmol) of 2-ethyl-4-phenyl-1-indanone in 60 ml of ethanol was dropwise added to the system at room temperature in a nitrogen atmosphere. After the addition was completed, the temperature of the system was raised to 50 °C to perform reaction for another 3.5 hours. After the reaction, the reaction solution was cooled, and acetone was dropwise added thereto to decompose the unreacted sodium boron hydride. Then, the reaction mixture was concentrated under reduced pressure, and extracted by the addition of 150 ml of water and 150 ml of ether. After the organic phase was separated, the aqueous phase was extracted twice with 100 ml of ether. The whole organic phase was washed with 300 ml of a saturated salt solution, and dried with anhydrous Na<sub>2</sub>SO<sub>4</sub>. The solvent was distilled off under reduced pressure, to obtain 32 g of the aimed product (mixture of two kinds of isomers) as a viscous light yellow liquid (yield: 99 %).

The physical properties of the product obtained are as follows.

NMR (CDCl<sub>3</sub>, 90 MHz):

δ = 1.02 (t, J = 7.1 Hz, 3H, CH<sub>3</sub>); 1.31 - 3.28 (m, 5H); 4.86, 5.03 (each d, J = 6.4 Hz, 5.1 Hz, respectively, total 1H,



7.10 - 7.66 (m, 8H)  
IR (Neat): 3,340 cm<sup>-1</sup> (ν<sub>C=O</sub>)

#### Synthesis of 2-ethyl-4-phenylindene

To a 1-liter four-necked round flask (equipped with a stirrer, a dropping funnel and a thermometer) were fed 29.3 g (123.9 mmol) of 2-ethyl-1-hydroxy-4-phenylindane, 51.6 g (371.4 mmol) of triethylamine, 0.75 g (6.3 mmol) of 4-dimethylaminopyridine and 294 ml of methylene chloride. Then, a solution obtained by dissolving 19.2 ml (247.5 mmol) of methanesulfonyl chloride in 19.5 ml of methylene chloride was dropwise added slowly to the system while cooling with ice in a nitrogen atmosphere. After the addition was completed, the resulting mixture was reacted for another 3.5 hours at the same temperature. The reaction mixture was poured in 500 ml of ice water, then the organic phase was separated, and the aqueous phase was further extracted twice with 150 ml of methylene chloride. The whole organic phase was successively washed with a saturated NaHCO<sub>3</sub> solution and a saturated salt solution, and dried with anhydrous Na<sub>2</sub>SO<sub>4</sub>. The solvent was distilled off under reduced pressure, and the residue was separated by silica gel chromatography (developed with hexane), to obtain 19.7 g of the aimed product (mixture of two kinds of isomers) as a light yellow liquid (yield: 73 %).

The physical properties of the product obtained are as follows.

NMR (CDCl<sub>3</sub>, 90 MHz):

δ = 1.20 (t, J = 7.6 Hz, 3H, CH<sub>3</sub>); 2.49 (q, J = 7.6 Hz, 2H); 3.41 (s, 2H); 6.61, 6.72 (each bs, total 1H); 7.09 - 8.01 (m, 8H)

#### Synthesis of dimethylsilyl-bis(2-ethyl-4-phenylindene)

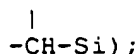
To a 500-ml three-necked round flask (equipped with a stirrer tip, a Zimroth condenser, a dropping funnel and a thermometer) were fed 15 g (68.4 mmol) of 2-ethyl-4-phenylindene, 240 mg (1.89 mmol) of copper thiocyanate and 150 ml of anhydrous ether. Then, 47.1 ml (75.3 mmol) of a hexane solution of n-butyllithium having a concentration of 1.6 M was dropwise added slowly to the system while cooling with ice in a nitrogen atmosphere. After the addition was completed, the temperature of the system was raised to room temperature to perform reaction for another 1 hour. Then, to the reaction mixture was dropwise added slowly a solution obtained by 4.56 ml (37.8 mmol) of dimethyldichlorosilane

in 13.5 ml of anhydrous ether. After the addition was completed, the mixture was further reacted for 12 hours at room temperature. The reaction mixture was filtered with Celite, and the filtrate was poured in 150 ml of saturated ammonium chloride water. After the organic phase was separated, the aqueous phase was extracted with 150 ml of ether. The whole organic phase was washed with a saturated salt solution, and dried with anhydrous  $\text{Na}_2\text{SO}_4$ . The solvent was distilled off under reduced pressure, and the residue was separated by silica gel chromatography (developed with hexane  $\rightarrow$  hexane/methylene chloride (20/1, by parts by volume)), to obtain 13.5 g of the aimed product (mixture of two kinds of isomers) as a light yellow solid (yield: 80 %).

The physical properties of the product obtained are as follows.

NMR ( $\text{CDCl}_3$ , 90 MHz) :

$\delta = -0.23, -0.17$  (each s, total 6H, Si- $\text{CH}_3$ ); 1.12, 1.19 (each t, each J = 7.4 Hz, total 6H,  $\text{CH}_3$ ); 2.44 (bq, J = 7.4 Hz, 4H); 3.81 (s, 2H,



6.75 (bs, 2H, 3-H-Ind); 6.88 - 7.74 (m, 16H)

#### Synthesis of rac-dimethylsilyl-bis(2-ethyl-4-phenylindenyl)zirconium dichloride

To a 200-ml three-necked round flask (equipped with a stirrer tip, a ball condenser, a dropping funnel and a thermometer) were fed 2.52 g (5.07 mmol) of dimethylsilyl-bis(2-ethyl-4-phenylindene) and 51 ml of anhydrous ether in an argon atmosphere. Then, 6.75 ml (10.68 mmol) of a hexane solution of n-butyllithium having a concentration of 1.58 M was dropwise added slowly to the system at room temperature. After the addition, the resulting mixture was further reacted for 13.5 hours. The reaction solution was cooled in a dry ice-acetone bath to  $-70^\circ\text{C}$ , and thereto was slowly added 1.185 g (5.07 mmol) of a  $\text{ZrCl}_4$  powder. After the addition was completed, the mixture was left overnight with stirring. Then, the solvent was distilled off at room temperature under reduced pressure. After addition of 90 ml of methylene chloride, the insolubles were filtered and the filtrate was concentrated at room temperature to give a solid. The solid was filtered, then washed twice with 5 ml of anhydrous ether, and dried under reduced pressure to obtain 0.68 g of the aimed product as an orange-yellow solid (yield: 20 %).

The physical properties of the product obtained are as follows.

NMR ( $\text{CDCl}_3$ , 90 MHz):

$\delta = 1.09$  (t, J = 7.3 Hz, 6H,  $\text{CH}_3$ ); 1.34 (s, 6H, Si- $\text{CH}_3$ ); 2.46 (quin, J = 7.3 Hz, 2H); 2.73 (quin, J = 7.3 Hz, 2H); 6.96 (s, 2H, 3-H-Ind); 6.99 - 7.88 (m, 16H)

#### Polymerization

To a 100-liter stainless steel polymerizer was fed 50 liters of toluene in a nitrogen atmosphere, and the system was cooled to  $0^\circ\text{C}$ . Then, propylene and hydrogen were fed to the system for 2 hours at feed rates of  $4\text{ Nm}^3/\text{hr}$  and  $400\text{ Nl/hr}$ , respectively, to saturate the system sufficiently. After the feed rate of propylene was reduced to  $2\text{ Nm}^3/\text{hr}$ , to the system were added 15.0 mmol of triisobutylaluminum, 30.0 mmol (in terms of Al atoms) of methylaluminoxane and 0.10 mmol (in terms of Zr atoms) of rac-dimethylsilyl-bis(2-ethyl-4-phenylindenyl)zirconium dichloride to perform polymerization for 1 hour while keeping the system at  $0^\circ\text{C}$ . The polymerization was terminated by adding 0.5 liter of methanol to the system. The resulting polymer suspension was allowed to stand for 6 hours while purging the system with nitrogen. Then, about a half amount of toluene was taken out by decantation, and the remaining polymer suspension was transferred into a 200-liter reactor containing therein 0.1 liter of a hydrochloric acid and 60 liters of methanol, followed by stirring for 30 minutes. After the polymer suspension was allowed to stand and subjected to decantation, the suspension was again subjected to washing with 50 liters of methanol and decantation. Then, the polymer suspension was taken out from the bottom of the reactor, and the solvent was separated by filtration. The resulting polymer was dried at  $100^\circ\text{C}$  under a high vacuum for one day.

The amount of the propylene homopolymer [propylene polymer (7)] obtained was 1,950 g, and the polymerization activity corresponded to  $19,500\text{ g-PP/mmol-Zr}$ . This polymer had  $[\eta]$  of  $0.68\text{ dl/g}$ , MFR of  $900\text{ g/10 min}$  and  $\text{Mw/Mn}$  of 2.02. In this polymer, the triad tacticity was 99.5 %, the proportion of the irregularly positioned units based on the 2,1-insertion of the propylene monomer was 0.11 %, and the proportion of the irregularly positioned units based on the 1,3-insertion of the propylene monomer was below the detected lower limit (less than 0.03 %).

## [Preparation of a propylene polymer (8)]

The procedures of the polymerization and the post treatment for preparing the propylene polymer (7) described above were repeated except that the feed rate of hydrogen was varied to 90 Nl/hr.

The amount of the propylene homopolymer [propylene polymer (8)] thus obtained corresponded to 2,720 g, and the polymerization activity corresponded to 27,200 g-PP/mmol-Zr. This polymer had  $[\eta]$  of 3.25 dl/g, MFR of 0.75 g/10 min and Mw/Mn of 2.20. In this polymer, the triad tacticity was 99.6 %, the proportion of the irregularly positioned units based on the 2,1-insertion of the propylene monomer was 0.16 %, and the proportion of the irregularly positioned units based on the 1,3-insertion of the propylene monomer was below the detected lower limit (less than 0.03 %).

## [Preparation of a propylene polymer (12)]

To a 100-liter stainless steel polymerizer was fed 50 liters of toluene, and the system was cooled to 0 °C. Then, propylene, ethylene and hydrogen were fed to the system for 2 hours at feed rates of 4 Nm<sup>3</sup>/hr, 2 Nm<sup>3</sup>/hr and 10 Nl/hr, respectively, to saturate the system sufficiently. The feed rates of propylene and ethylene were reduced to 1 Nm<sup>3</sup>/hr and 300 Nl/hr, respectively, and the system was allowed to stand for 1 hour. Then, to the system were added 8.0 mmol of triisobutylaluminum, 12.0 mmol (in terms of Al atoms) of methylaluminoxane and 0.040 mmol (in terms of Zr atoms) of rac-dimethylsilyl-bis(2-ethyl-4-phenylindenyl)zirconium dichloride, to perform polymerization for 1 hour while keeping the system at 0 °C. The termination of the polymerization and the post treatment were carried out in the same manner as described for the propylene polymer (7).

The amount of the propylene copolymer [propylene polymer (12)] thus obtained was 1,550 g, and the polymerization activity corresponded to 38,700 g-polymer/mmol-Zr. This polymer had  $[\eta]$  of 0.68 dl/g, MFR of 950 g/10 min and Mw/Mn of 2.33, and contained constituent units derived from ethylene in an amount of 5.1 % by mol. In this polymer, the triad tacticity was 99.2 %, the proportion of the irregularly positioned units based on the 2,1-insertion of the propylene monomer was 0.08 %, and the proportion of the irregularly positioned units based on the 1,3-insertion of the propylene monomer was below the detected lower limit (less than 0.03 %).

## [Preparation of a propylene polymer (13)]

To a 100-liter stainless steel polymerizer was fed 35 liters of toluene, and the system was cooled to 0 °C. Then, propylene and ethylene were fed to the system for 2 hours at feed rates of 4 Nm<sup>3</sup>/hr and 2 Nm<sup>3</sup>/hr, respectively, while adjusting the pressure in the system at 2.5 kg/cm<sup>2</sup>-G, so as to saturate the system sufficiently. The feed rates of propylene and ethylene were reduced to 1 Nm<sup>3</sup>/hr and 300 Nl/hr, respectively, and the system was allowed to stand for 1 hour. Then, to the system were added 5.0 mmol of triisobutylaluminum, 10.0 mmol (in terms of Al atoms) of methylaluminoxane and 0.010 mmol (in terms of Zr atoms) of rac-dimethylsilyl-bis(2-ethyl-4-phenylindenyl)zirconium dichloride, to perform polymerization for 1 hour at 0 °C while adjusting the pressure in the polymerizer at 2.5 kg/cm<sup>2</sup>-G. After the polymerization was terminated by methanol, the pressure in the system was released, and the system was purged with nitrogen. The post treatment was carried out in the same manner as described for the propylene polymer (7).

The amount of the propylene copolymer [propylene polymer (13)] thus obtained was 1,310 g, and the polymerization activity corresponded to 13,100 g-polymer/mmol-Zr. This polymer had  $[\eta]$  of 3.10 dl/g, MFR of 0.72 g/10 min and Mw/Mn of 2.3, and contained constituent units derived from ethylene in an amount of 5.6 % by mol. In this polymer, the triad tacticity was 99.3 %, the proportion of the irregularly positioned units based on the 2,1-insertion of the propylene monomer was 0.13 %, and the proportion of the irregularly positioned units based on the 1,3-insertion of the propylene monomer was below the detected lower limit (less than 0.03 %).

## [Preparation of a propylene polymer (14)]

The procedures of the polymerization and the post treatment for preparing the propylene polymer (12) described above were repeated except that hydrogen was not used.

The amount of the propylene copolymer [propylene polymer (14)] thus obtained was 1,750 g, and the polymerization activity corresponded to 17,500 g-polymer/mmol-Zr. This polymer had  $[\eta]$  of 1.67 dl/g, MFR of 9.5 g/10 min and Mw/Mn of 2.10, and contained constituent units derived from ethylene in an amount of 5.6 % by mol. In this polymer, the triad tacticity was 99.2 %, the proportion of the irregularly positioned units based on the 2,1-insertion of the propylene monomer was 0.11 %, and the proportion of the irregularly positioned units based on the 1,3-insertion of the propylene monomer was below the detected lower limit (less than 0.03 %).

[Preparation of a soft polymer (ethylene/propylene random copolymer)]

Preparation of a solid titanium catalyst component

23.8 g of anhydrous magnesium chloride, 122 ml of decane and 116.1 g of 2-ethylhexyl alcohol were together heated at 130 °C for 2 hours to give a homogeneous solution. To the solution was added 5.72 ml of ethyl benzoate. The resulting homogeneous solution was dropwise added to 1 liter of titanium tetrachloride kept at -20 °C over a period of 20 minutes with stirring, and the resulting solution was further stirred for 1 hour at -20 °C. Then, the temperature of the solution was slowly raised. When the temperature of the solution reached 80 °C, 12.2 ml of ethyl benzoate was further added to the solution, and the mixture was stirred for 2 hours at 80 °C.

After the reaction was completed, the solid material was collected by filtration. The solid material was resuspended in 1 liter of titanium tetrachloride, and the suspension was stirred for 2 hours at 90 °C. The solid material was again collected by filtration and washed sufficiently with purified hexane until any titanium compound liberated in the washing liquid was not detected.

The solid titanium catalyst component thus obtained contained titanium, chlorine, magnesium and ethyl benzoate in amounts of 3.7 % by weight, 59 % by weight, 17 % by weight and 15 % by weight, respectively.

Polymerization

In a 15-liter stainless steel polymerizer equipped with a stirrer, copolymerization of ethylene and propylene was carried out.

To the polymerizer were continuously fed, through the top thereof, hexane as a polymerization solvent at a feed rate of 3 l/hr, a hexane slurry of the solid titanium catalyst component obtained above (0.15 mmol/l in terms of titanium atom) at a feed rate of 1 l/hr, a hexane solution of triethylaluminum (15 mmol/l) at a feed rate of 0.5 l/hr and a hexane solution of ethyl benzoate (5 mmol/l) at a feed rate of 0.5 l/hr. Further, to the polymerizer were continuously fed, through the top thereof, ethylene at a feed rate of 90 l/hr and propylene at a feed rate of 270 l/hr, and was also continuously fed hydrogen so that the hydrogen concentration in the gas phase of the polymerizer was 2.3 %.

On the other hand, the polymer solution was continuously drawn out from the bottom of the polymerizer so that the amount of the polymer solution in the polymerizer was 5 liters.

The copolymerization was carried out at 80 °C by circulating warm water within a jacket equipped on the outside of the polymerizer. The pressure in the polymerizer was 6.5 kg/cm<sup>2</sup>-G.

To the polymer solution drawn out from the polymerizer was added a small amount of methanol to terminate the polymerization reaction. The polymer solution was subjected to steam stripping to separate the polymer from the solvent, and the polymer was dried at 80 °C under reduced pressure for one day.

Through the above operation, an ethylene/propylene random copolymer (EPR-1) was obtained in an amount of 235 g/hr.

The ethylene/propylene random copolymer (EPR-1) contained constituent units derived from ethylene in an amount of 42 % by mol, and had  $[\eta]$  of 2.7 dl/g.

[Synthesis of an ethylene/propylene random copolymer (EPR-3)]

In a 2-liter autoclave equipped with a stirrer, copolymerization of ethylene and propylene was carried out.

In detail, to the autoclave were fed, through the top thereof, 0.9 liter of dehydrated and purified hexane, 1 ml of a hexane solution of triisobutylaluminum (1 mmol/ml) and 0.27 ml of a toluene solution of methylaluminoxane (0.9 mmol/ml in terms of Al atoms). After the temperature of the system was raised to 50 °C, propylene was fed to the system so that the total pressure was 3.8 kg/cm<sup>2</sup>-G, and ethylene was further fed to the system so that the total pressure was 8 kg/cm<sup>2</sup>-G. Then, to the system was added 0.0008 mmol (in terms of zirconium) of rac-dimethylsilyl-bis(2-ethyl-4-phenylindenyl)zirconium dichloride to perform polymerization for 30 minutes with keeping the temperature at 50 °C and the total pressure at 8 kg/cm<sup>2</sup>. After release of pressure, the polymer solution was added to a large amount of methanol. The resulting polymer was taken out and dried at 130 °C for 12 hours under reduced pressure.

The yield of the ethylene/propylene random copolymer (EPR-3) thus obtained was 49.6 g. This copolymer contained constituent units derived from ethylene in an amount of 39 % by mol, and had  $[\eta]$  of 3.1 dl/g and MFR of 0.4 g/10 min.

[Synthesis of an ethylene/propylene random copolymer (EPR-5)]

In a 2-liter autoclave equipped with a stirrer, copolymerization of ethylene and propylene was carried out.

In detail, to the polymerizer were fed, through the top thereof, 1 liter of dehydrated and purified hexane, 11 ml of

propylene in the form of a gas, 0.85 ml of a hexane solution of triisobutylaluminum (1 mmol/ml) and 0.13 ml of a toluene solution of methylaluminoxane (1.2 mmol/ml in terms of Al atoms). After the temperature of the system was raised to 80 °C, ethylene was fed to the system so that the total pressure was 8 kg/cm<sup>2</sup>-G. Then, to the system was added 0.0005 mmol (in terms of Zr atoms) of rac-dimethylsilyl-bis(2-ethyl-4-phenylindenyl)zirconium dichloride to perform polymerization for 30 minutes with keeping the temperature at 80 °C and the total pressure at 8 kg/cm<sup>2</sup>-G. After release of pressure, the polymer solution was added to a large amount of methanol. The resulting polymer was taken out and dried at 130 °C for 12 hours under reduced pressure.

The yield of the ethylene/propylene random copolymer (EPR-5) thus obtained was 58.4 g. This copolymer contained constituent units derived from ethylene in an amount of 79 % by mol, and had  $[\eta]$  of 2.2 dl/g and MFR of 0.7 g/10 min.

#### [Synthesis of ethylene polymers (PE-1) and (PE-2)]

Ethylene polymers (PE-1) and (PE-2) were synthesized by a conventional ethylene copolymerization process using a combined catalyst of MgCl<sub>2</sub>-supported Ti catalyst-triethylaluminum.

The ethylene polymer (PE-1) had  $[\eta]$  of 1.20 dl/g, MFR of 29 g/10 min and Mw/Mn of 4.1.

The ethylene polymer (PE-2) had  $[\eta]$  of 2.11 dl/g, MFR of 1.3 g/10 min and Mw/Mn of 4.8.

#### Example 1

A propylene polymer composition consisting of 40 parts by weight of the propylene polymer (1), 60 parts by weight of the propylene polymer (2) and 20 parts by weight of the soft polymer (EPR-1) prepared by the above polymerization was molded into ASTM specimens by an injection molding machine under conditions of a resin temperature of 200°C and a mold temperature of 40°C, to measure the physical properties.

The results are set forth in Table 1.

#### Comparative Example 1

A propylene polymer composition consisting of 100 parts by weight of the propylene polymer (3) and 20 parts by weight of the soft polymer (EPR-1) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties.

The results are set forth in Table 1.

#### Comparative Example 2

A propylene polymer composition consisting of 40 parts by weight of the propylene polymer (4), 60 parts by weight of the propylene polymer (5) and 20 parts by weight of the soft polymer (EPR-1) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties.

The results are set forth in Table 1.

Table 1

|                       |                       | Ex. 1  | Comp.Ex. 1 | Comp.Ex 2 |
|-----------------------|-----------------------|--------|------------|-----------|
| Propylene polymer (1) |                       | 40     | -          | -         |
| Propylene polymer (2) |                       | 60     | -          | -         |
| Propylene polymer (3) |                       | -      | 100        | -         |
| Propylene polymer (4) |                       | -      | -          | 40        |
| Propylene polymer (5) |                       | -      | -          | 60        |
| Soft polymer          |                       | 20     | 20         | 20        |
| MFR                   | (g/10 min)            | 15     | 25         | 12        |
| FM                    | (kg/cm <sup>2</sup> ) | 11,000 | 9,100      | 13,000    |
| IZ (23°C)             | (kg-cm/cm)            | 35     | 37         | 12        |
| EL                    | (%)                   | 720    | 740        | 180       |
| HDT (load: 4.6 kg)    | (°C)                  | 95     | 88         | 110       |



Example 2

A propylene polymer composition consisting of 50 % by weight of the propylene polymer (4) and 50 % by weight of the propylene polymer (2) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties.

The results are set forth in Table 2.

Comparative Example 3

A propylene polymer composition consisting of 50 % by weight of the propylene polymer (4) and 50 % by weight of the propylene polymer (5) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties.

The results are set forth in Table 2

Table 2

|                         |                       | Ex. 2  | Comp. Ex. 3 |
|-------------------------|-----------------------|--------|-------------|
| Propylene polymer (4)   |                       | 50     | 50          |
| Propylene polymer (2)   |                       | 50     | -           |
| Propylene polymer (5)   |                       | -      | 50          |
| MFR                     | (g/10 min)            | 15     | 15          |
| FM                      | (kg/cm <sup>2</sup> ) | 18,000 | 19,000      |
| IZ                      | (23°C) (kg-cm/cm)     | 2      | 2           |
| EL                      | (%)                   | 180    | 28          |
| HDT (load: 4.6 kg) (°C) |                       | 115    | 115         |

Example 3

A propylene polymer composition consisting of 50 parts by weight of the propylene polymer (4), 50 parts by weight of the propylene polymer (2) and 20 parts by weight of the soft polymer (EPR-1) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties.

The results are set forth in Table 3.

Comparative Example 4

A propylene polymer composition consisting of 50 parts by weight of the propylene polymer (4), 50 parts by weight of the propylene polymer (5) and 20 parts by weight of the soft polymer (EPR-1) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, and to measure the physical properties.

The results are set forth in Table 3

Table 3

|                         |                       | Ex. 3  | Comp. Ex. 4 |
|-------------------------|-----------------------|--------|-------------|
| Propylene polymer (4)   |                       | 50     | 50          |
| Propylene polymer (2)   |                       | 50     | -           |
| Propylene polymer (5)   |                       | -      | 50          |
| Soft polymer            |                       | 20     | 20          |
| MFR                     | (g/10 min)            | 12     | 15          |
| FM                      | (kg/cm <sup>2</sup> ) | 12,500 | 13,000      |
| IZ (23°C)               | (kg-cm/cm)            | 30     | 12          |
| EL                      | (%)                   | 400    | 180         |
| HDT (load: 4.6 kg) (°C) |                       | 95     | 105         |

Example 4

A propylene polymer composition consisting of 50 parts by weight of the propylene polymer (7), 50 parts by weight of the propylene polymer (8) and 20 parts by weight of the ethylene/propylene random copolymer (EPR-1) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties.

The results are set forth in Table 4.

Example 5

A propylene polymer composition consisting of 50 parts by weight of the propylene polymer (7), 50 parts by weight of the propylene polymer (8), 10 parts by weight of the ethylene/propylene random copolymer (EPR-3) and 10 parts by weight of the ethylene/propylene random copolymer (EPR-5) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties.

The results are set forth in Table 4.

Table 4

|                         |                       | Ex. 4  | Ex. 5  |
|-------------------------|-----------------------|--------|--------|
| Propylene polymer (7)   |                       | 50     | 50     |
| Propylene polymer (8)   |                       | 50     | 50     |
| EPR-1                   |                       | 20     | -      |
| EPR-3                   |                       | -      | 10     |
| EPR-5                   |                       | -      | 10     |
| MFR                     | (g/10 min)            | 9.1    | 9.1    |
| FM                      | (kg/cm <sup>2</sup> ) | 12,800 | 13,600 |
| IZ (23°C)               | (kg-cm/cm)            | 38     | 34     |
| EL                      | (%)                   | 720    | 560    |
| HDT (load: 4.6 kg) (°C) |                       | 98     | 104    |

Example 6

A propylene polymer composition consisting of 50 parts by weight of the propylene polymer (12), 50 parts by weight of the propylene polymer (13) and 20 parts by weight of the ethylene/propylene random copolymer (EPR-1) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties. Further, a film was produced from the above composition under the following conditions, to measure the haze.

The film (width: 30 cm, thickness: 50  $\mu$ m) was produced by means of a single-screw extruder having a diameter of 30 mm equipped with a T-die under the conditions of a cooling roll temperature of 25 °C and a take-up rate of 3m/min.

The results are set forth in Table 5.

Comparative Example 5

A propylene polymer composition consisting of 100 parts by weight of the propylene polymer (14) and 20 parts by weight of the ethylene/propylene random copolymer (EPR-1) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties. Further, a film was produced from the above composition in the same manner as described in Example 6, to measure the haze.

The results are set forth in Table 5.

Table 5

|                        | Ex. 6 | Comp. Ex. 5 |
|------------------------|-------|-------------|
| Propylene polymer (12) | 50    | -           |
| Propylene polymer (13) | 50    | -           |

Table 5 (continued)

|                        |                       | Ex. 6 | Comp. Ex. 5 |
|------------------------|-----------------------|-------|-------------|
| Propylene polymer (14) |                       | -     | 100         |
| EPR-1                  |                       | 20    | 20          |
| MFR                    | (g/10 min)            | 13.0  | 7.2         |
| FM                     | (kg/cm <sup>2</sup> ) | 6,200 | 5,600       |
| IZ (23°C)              | (kg-cm/cm)            | 38    | 46          |
| EL                     | (%)                   | 520   | 540         |
| Film haze              | (%)                   | 0.7   | 2.0         |

Example 7

A propylene polymer composition consisting of 50 parts by weight of the propylene polymer (7), 50 parts by weight of the propylene polymer (8), 10 parts by weight of the ethylene/propylene random copolymer (EPR-1) and 10 parts by weight of the ethylene polymer (PE-1) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties.

The results are set forth in Table 6.

Example 8

A propylene polymer composition consisting of 50 parts by weight of the propylene polymer (7), 50 parts by weight of the propylene polymer (8), 10 parts by weight of the ethylene/propylene random copolymer (EPR-3) and 10 parts by weight of the ethylene polymer (PE-2) prepared by the above polymerization was molded into ASTM specimens in the same manner as described in Example 1, to measure the physical properties.

The results are set forth in Table 6.

Table 6

|                         |                       | Ex. 7  | Ex. 8  |
|-------------------------|-----------------------|--------|--------|
| Propylene polymer (7)   |                       | 50     | 50     |
| Propylene polymer (8)   |                       | 50     | 50     |
| EPR-1                   |                       | 15     | -      |
| EPR-3                   |                       | -      | 15     |
| PE-1                    |                       | 10     | -      |
| PE-2                    |                       | -      | 10     |
| MFR                     | (g/10 min)            | 9.7    | 9.5    |
| FM                      | (kg/cm <sup>2</sup> ) | 13,900 | 13,800 |
| IZ (23°C)               | (kg-cm/cm)            | 35     | 37     |
| EL                      | (%)                   | 440    | 480    |
| HDT (load: 4.6 kg) (°C) |                       | 105    | 10     |

**Claims**

1. A propylene polymer composition comprising:  
10 to 90 parts by weight of (A1) a propylene polymer which is characterized in that:

(1) the propylene polymer (A1) is obtained by polymerizing propylene in the presence of an olefin polymerization catalyst comprising:

(i)

(a) a compound of a Group IVB transition metal in the periodic table containing a ligand having a cyclopent-

tadienyl skeleton, and

(ii) at least one compound selected from

- (b) an organoaluminum oxy-compound, and
- (c) a compound which reacts with the transition metal compound (a) to form an ion pair,

(2) the propylene polymer (A1) has a melt flow rate (MFR), as measured at 230°C under a load of 2.16 kg, of 0.01 to 30 g/10 min, and

(3) the propylene polymer (A1) has a molecular weight distribution (Mw/Mn), as measured by gel permeation chromatography (GPC), of 2 to 3;

10 to 90 parts by weight of (A2) a propylene polymer which is characterized in that:

(1) the propylene polymer (A2) is obtained by polymerizing propylene in the presence of an olefin polymerization catalyst comprising:

(i)

- (a) a compound of a Group IVB transition metal in the periodic table containing a ligand having a cyclopentadienyl skeleton, and

(ii) at least one compound selected from

- (b) an organoaluminum oxy-compound, and
- (c) a compound which reacts with the transition metal compound (a) to form an ion pair,

(2) the propylene polymer (A2) has a melt flow rate (MFR), as measured at 230°C under a load of 2.16 kg, of 30 to 1,000 g/10 min, and

(3) the propylene polymer (A2) has a molecular weight distribution (Mw/Mn), as measured by gel permeation chromatography (GPC), of 2 to 4; and

3 to 30 parts by weight of (B) a soft polymer which is a (co)polymer of an  $\alpha$ -olefin of 2 to 20 carbon atoms having an MFR, as measured at 190°C under a load of 2.16 kg, of 0.01 to 100 g/10 min and a crystallinity, as measured by X-ray diffractometry, of less than 30%,

the ratio ((A2)/(A1)) of the MFR of said propylene polymer (A2) to the MFR of said propylene polymer (A1) being not less than 30.

2. An injection molded article formed from a propylene polymer composition comprising:

10 to 90% by weight of (A3) a propylene polymer which is characterized in that:

(1) the propylene polymer (A3) is obtained by polymerizing propylene in the presence of an olefin polymerization catalyst comprising:

- (d) a solid titanium catalyst component, and
- (e) an organometallic compound catalyst component,

(2) the propylene polymer (A3) has a melt flow rate (MFR), as measured at 230°C under a load of 2.16 kg, of 0.01 to 30 g/10 min, and

(3) the propylene polymer (A3) has a molecular weight distribution (Mw/Mn), as measured by gel permeation chromatography (GPC), of 4 to 15; and

the propylene polymer (A2) as defined in claim 1, in an amount of 90 to 10% by weight.

3. A propylene polymer composition comprising:

the propylene polymer (A3) as defined in claim 2, in an amount of 10 to 90 parts by weight;  
the propylene polymer (A2) as defined in claim 1, in an amount of 90 to 10 parts by weight; and

(B) a soft polymer which is a (co)polymer of an  $\alpha$ -olefin of 2 to 20 carbon atoms having an MFR, as measured at 190°C under a load of 2.16 kg, of 0.01 to 100 g/10 min and a crystallinity, as measured by X-ray diffractometry, of less than 30%, in an amount of 3 to 30 parts by weight.

## Patentansprüche

### 1. Propylenpolymermasse, umfassend

10 bis 90 Gewichtsteile eines Propylenpolymers (A1), das dadurch gekennzeichnet ist, daß

(1) das Propylenpolymer (A1) erhalten worden ist durch Polymerisieren von Propylen in Gegenwart eines Olefinpolymerisationskatalysators, umfassend:

(i)

(a) eine Verbindung eines Übergangsmetalls der Gruppe IVB des Periodensystems, enthaltend einen Liganden mit einem Cyclopentadienylgerüst, und

(ii) mindestens eine Verbindung, ausgewählt aus

(b) einer Organoaluminiumoxyverbindung und

(c) einer Verbindung, die mit der Übergangsmetallverbindung (a) reagiert unter Bildung eines Ionenpaares,

(2) das Propylenpolymer (A1) eine Fließfähigkeit (MFR), gemessen bei 230°C unter einer Last von 2,16 kg, von 0,01 bis 30 g/10 min aufweist, und

(3) das Propylenpolymer (A1) eine Molekulargewichtsverteilung (Mw/Mn), gemessen durch Gelpermeationschromatographie (GPC), von 2 bis 3 aufweist,

10 bis 90 Gewichtsteile eines Propylenpolymers (A2), das dadurch gekennzeichnet ist, daß:

(1) das Propylenpolymer (A2) erhalten worden ist durch Polymerisieren von Propylen in Gegenwart eines Olefinpolymerisationskatalysators, umfassend:

(i)

(a) eine Verbindung eines Übergangsmetalls der Gruppe IVB des Periodensystems, enthaltend einen Liganden mit einem Cyclopentadienylgerüst, und

(ii) mindestens eine Verbindung, ausgewählt aus

(b) einer Organoaluminiumoxyverbindung und

(c) einer Verbindung, die mit der Übergangsmetallverbindung (a) reagiert unter Bildung eines Ionenpaares,

(2) das Propylenpolymer (A2) eine Fließfähigkeit (MFR), gemessen bei 230°C unter einer Last von 2,16 kg, von 30 bis 1 000 g/10 min aufweist, und

(3) das Propylenpolymer (A2) eine Molekulargewichtsverteilung (Mw/Mn), gemessen durch Gelpermeationschromatographie (GPC), von 2 bis 4 aufweist, und

3 bis 30 Gewichtsteile eines weichen Polymers (B), das ein (Co)polymer eines  $\alpha$ -Olefins mit 2 bis 20 Kohlenstoffatomen ist und eine MFR, gemessen bei 190°C unter einer Last von 2,16 kg, von 0,01 bis 100 g/10 min und eine Kristallinität, gemessen durch Röntgenbeugung, von weniger als 30 % aufweist,

wobei das Verhältnis ((A2)/(A1)) der MFR des Propylenpolymers (A2) zu der MFR des Propylenpolymers (A1) nicht kleiner ist als 30.

### 2. Durch Spritzguß geformter Gegenstand aus einer Propylenpolymermasse, umfassend:

10 bis 90 Gew.-% eines Propylenpolymers (A3), das dadurch gekennzeichnet ist, daß

(1) das Propylenpolymer (A3) erhalten worden ist durch Polymerisieren von Propylen in Gegenwart eines Olefinpolymerisationskatalysators, umfassend:

- (d) eine feste Titankatalysatorkomponente und
- (e) eine metallorganische Katalysatorkomponente,

(2) das Propylenpolymer (A3) eine Fließfähigkeit (MFR), gemessen bei 230°C unter einer Last von 2,16 kg, von 0,01 bis 30 g/10 min aufweist, und

(3) das Propylenpolymer (A3) eine Molekulargewichtsverteilung (Mw/Mn), gemessen durch Gelpermeationschromatographie (GPC), von 4 bis 15 aufweist, und

das Propylenpolymer (A2), wie in Anspruch 1 definiert, in einer Menge von 90 bis 10 Gew.-%.

### 3. Propylenpolymermasse, umfassend

das Propylenpolymer (A3), wie in Anspruch 2 definiert, in einer Menge von 10 bis 90 Gewichtsteilen, das Propylenpolymer (A2), wie in Anspruch 1 definiert, in einer Menge von 90 bis 10 Gewichtsteilen, und (B) ein weiches Polymer, das ein (Co)polymer eines  $\alpha$ -Olefins mit 2 bis 20 Kohlenstoffatomen ist mit einer MFR, gemessen bei 190°C unter einer Last von 2,16 kg, von 0,01 bis 100 g/10 min und einer Kristallinität, gemessen durch Röntgenbeugung, von weniger als 30 %, in einer Menge von 3 bis 30 Gewichtsteilen.

## Revendications

### 1. Composition de polypropylène comprenant :

de 10 à 90 parties en poids de (A1) un polypropylène qui est caractérisé en ce que :

(1) l'on obtient le polypropylène (A1) par polymérisation de propylène en présence d'un catalyseur de polymérisation d'oléfines comprenant :

(i)

(a) un composé de métal de transition du groupe IVB du tableau périodique, contenant un ligand qui comporte un squelette cyclopentadiényle, et

(ii) au moins un composé choisi parmi :

(b) un composé oxy-organoaluminique, et

(c) un composé qui réagit avec le composé de métal de transition (a) pour former une paire d'ions,

(2) le polypropylène (A1) présente un indice de fluidité à chaud (MFR), tel que mesuré à 230 °C sous une charge de 2,16 kg, de 0,01 à 30 g/10 min., et

(3) le polypropylène (A1) présente un indice de polymolécularité (Mp/Mn), tel que mesuré par chromatographie par perméation de gel (GPC), de 2 à 3 ;

de 10 à 90 parties en poids de (A2) un polypropylène qui est caractérisé en ce que :

(1) l'on obtient le polypropylène (A2) par polymérisation de propylène en présence d'un catalyseur de polymérisation d'oléfines comprenant :

(i)

(a) un composé de métal de transition du groupe IVB du tableau périodique, contenant un ligand qui comporte un squelette cyclopentadiényle, et

(ii) au moins un composé choisi parmi :

- (b) un composé oxy-organoaluminique, et
- (c) un composé qui réagit avec le composé de métal de transition (a) pour former une paire d'ions,

(2) le polypropylène (A2) présente un indice de fluidité à chaud (MFR), tel que mesuré à 230 °C sous une charge de 2,16 kg, de 30 à 1 000 g/10 min, et

(3) le polypropylène (A2) présente un indice de polymolécularité (Mp/Mn), tel que mesuré par chromatographie par perméation de gel (GPC), de 2 à 4 ; et

de 3 à 30 parties en poids de (B) d'un polymère mou qui est un (co)polymère d'une  $\alpha$ -oléfine comportant de 2 à 20 atomes de carbone, présentant un MFR, tel que mesuré à 190 °C sous une charge de 2,16 kg, de 0,01 à 100 g/10 min. et une cristallinité, telle que mesurée par diffraction des rayons X, inférieure à 30 %,

le rapport ((A2)/(A1)) entre le MFR dudit polypropylène (A2) et le MFR dudit polypropylène (A1) valant au moins 30.

2. Article moulé par injection formé à partir d'une composition de polypropylène comprenant :
- de 10 à 90 % en poids de (A3) un polypropylène qui est caractérisé en ce que :

(1) l'on obtient le polypropylène (A3) par polymérisation du propylène en présence d'un catalyseur de polymérisation d'oléfines comprenant :

- (d) un composant catalytique au titane solide, et
- (e) un composant catalytique de type composé organométallique,

(2) le polypropylène (A3) présente un indice de fluidité à chaud (MFR), tel que mesuré à 230 °C sous une charge de 2,16 kg, de 0,01 à 30 g/10 min, et

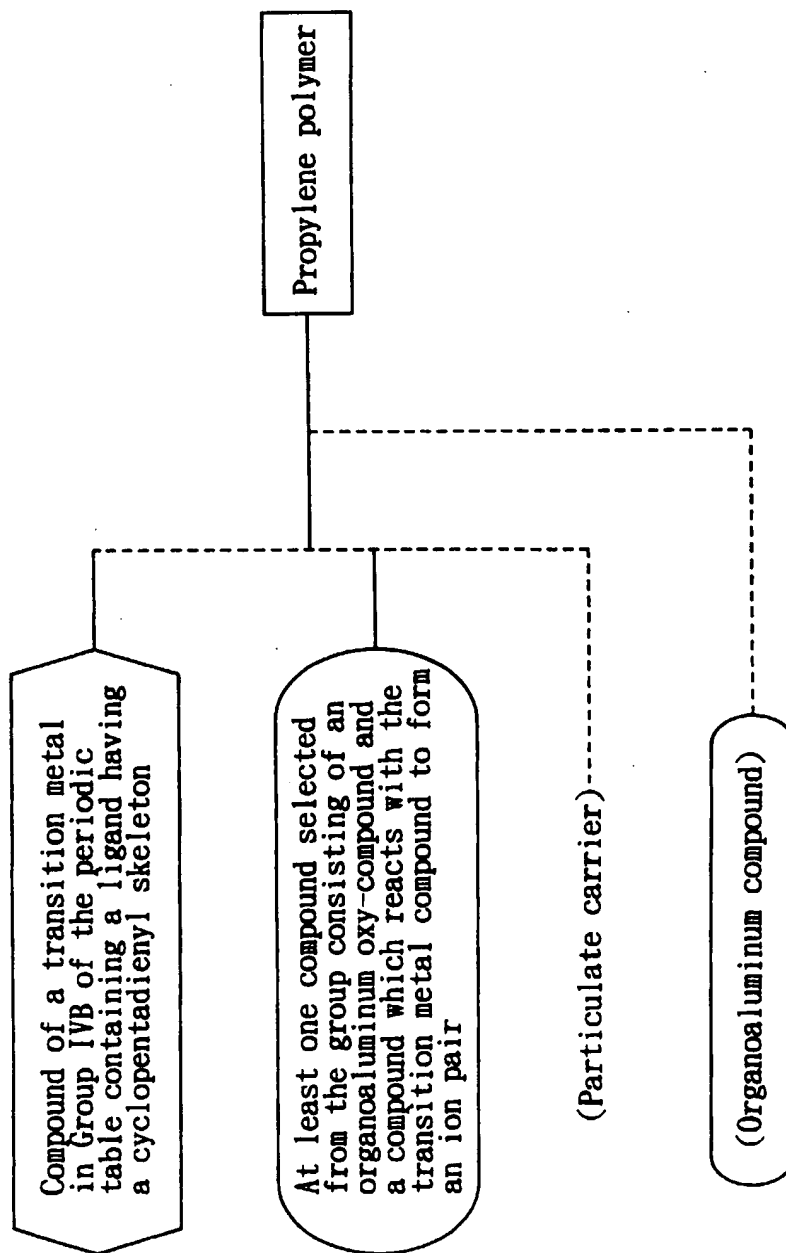
(3) le polypropylène (A3) présente un indice de polymolécularité (Mp/Mn), tel que mesuré par chromatographie par perméation de gel (GPC), de 4 à 15 ; et

le polypropylène (A2) tel que défini dans la revendication 1, en une quantité de 90 à 10 % en poids.

3. Composition de polypropylène comprenant :

le polypropylène (A3) tel que défini dans la revendication 2, en une quantité de 10 à 90 parties en poids ;  
le polypropylène (A2) tel que défini dans la revendication 1, en une quantité de 90 à 10 parties en poids ; et  
(B) un polymère mou qui est un (co)polymère d'une  $\alpha$ -oléfine comportant de 2 à 20 atomes de carbone, présentant un MFR, tel que mesuré à 190 °C sous une charge de 2,16 kg, de 0,01 à 100 g/10 min. et une cristallinité, telle que mesurée par diffraction des rayons X, inférieure à 30 %, en une quantité de 3 à 30 parties en poids.

*Fig. 1*





*Fig. 2*

